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N15 Cryogenic System and Technical Drawings

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Cryo Mechanical Group Text Documentation

The following (mostly Technical Specifications and Statements of Work) are text documents produced by the Mechanical Group of the Cryogenics Department. The equipment addressed are items which this Group was to have designed and procured. Drawings are documented elsewhere.

1. **Transfer Lines**
   Sector Shaft Transfer Line Design
   Statement of Work (SOW) for the Transfer Line Systems
   SOW for the Transfer Lines - Fabrication
   SOW for the Transfer Lines - Installation
2. **Cold Compressor System (CCS)**
   Technical Specification - Cold Compressor System
   Statement of Work - Cold Compressor System
3. **Cold Compressor Box (CCB)**
   Technical Specification - Cold Compressor Box
   SOW for the Cold Compressor Box
   SOW for the CCB - Fabrication
   SOW for the CCB - Installation
   SOW for the CCB - Prototype
4. **Underground Distribution Box (UDB)**
   Technical Specification - Tunnel Distribution Box
   SOW for the UDB - Fabrication
   SOW for the UDB - Installation
   SOW for the UDB - Prototype
5. **Nitrogen Subcooler Box (NSB)**
   SOW for the NSB - Fabrication
   SOW for the NSB - Installation
   SOW for the NSB - Prototype
6. **Nitrogen Dump Tanks (NDT)**
   SOW for the NDT - Fabrication
   SOW for the NDT- Installation
   SOW for the NDT - Prototype
7. **Tunnel Warm Lines (TWL)**
   Technical Specification for the Tunnel Warm Lines
8. **Installation**
   Installation Requirements for the Underground Cryogenic Equipment
9. **Molecular Sieve Vessel**
   Technical Specifications for the Molecular Sieve Vessel (2 pages)

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SECTOR SHAFT TRANSFER LINE DESIGN

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1. INTRODUCTION

The Superconducting Super Collider (SSC) is a high energy accelerator which produces head-on collisions of two proton beams each energized at an energy level of 20 TeV. Superconducting magnets are used to bend and focus the proton beams. A cryogenic system with unprecedented capacity is required to supply cryogens at 4 K, 20 K (helium) and 80 K (nitrogen) for both normal operation and transient conditions of these magnets and two thermal shields. The refrigeration system consists of twelve helium refrigeration plants and one or two air separation plants. The main ring of the collider is divided into ten sectors. Each sector is equipped with a cryogenic refrigeration plant at the X5 site. The two additional refrigeration plants are for the high energy booster (HEB). The air separation plant(s) will produce liquid nitrogen at an estimated rate of 5000 g/s for the collider consumption. At each sector, connection between the above-ground refrigeration plant and the below-ground collider main ring is accomplished by the Shaft Transfer Line (STL). The reliability of the STL is vital to the operation of the entire SSC cryogenic system. Characteristics of other large scale cylindrical cryostats are summarized in Table 1.1

Table 1.1 Characteristics of large scale cylindrical cryostats.

Cryostat	L_{total}	L_{vac}	L_{module}	O.D.	Shield	Heat leak per unit length (W/m)				
	(m)	(m)	(m)	(m)		2 K	4 K	20 K	40 K	80 K
LEP/CERN	>150									
CEBAF	1500	85-170	19.2	0.114- 0.406	S.S.	0.00559 0.0414				
HERA	6366	141	23.554	0.48	Al	N/A	0.17	N/A	1.3	1.0
TRISTAN	20	20	20	0.1652	Cu		0.15			
RHIC					Al.					
TEVTRON										
SSC		90	17	0.6858	Al	N/A			N/A	
SSC STL		30-100	12	0.6096	Cu	N/A			N/A	

This report presents the functionality, design requirements, and design calculations of the STL. System operating modes which dictate the design criteria for various elements of the STL are addressed. System requirements, design constraints, and results of analysis conducted on key elements are also discussed.

1.1 System Configuration

At each sector, the terminal element of the Surface Refrigeration System (SRS) is the Surface Distribution Box (SDB). On the collider side, four half-feed spool pieces (SPRF) will interface with the Below-Grade Subsystems (BGS) in the underground cryogenic chamber. The BGS includes the Cold

Compressor Box (CCB), Tunnel Distribution Box (TDB), Nitrogen Subcooler Box (NSB), Shaft and Tunnel Transfer Line Systems (STL and TTL), and two Nitrogen Dump Tanks (NDT). A flow diagram for these cryogenic facilities is shown in Figure 1.1.1

Figure 1.1.1 Flow diagram for cryogenic facilities in the underground enclosure

The shaft transfer line consists of two horizontal sections and one vertical section. The first horizontal section starts at the SDB and ends at the utility shaft. The vertical section follows the utility shaft wall all the way from top to bottom. The second horizontal section starts at the bottom of the utility shaft and ends at the CCB. The two horizontal sections are connected to the vertical section at the top and bottom of the utility shaft respectively by two elbow pieces. The elbow pieces complete the required 90° turns.

1.2 System Requirements

Helium and nitrogen are circulated in the collider main ring to maintain the operating temperatures of the magnets and their thermal shields. The design and nominal requirements on pressure, temperature, and mass flow rates for the seven cryogenic circuits of the shaft transfer line are tabulated in Table 1.2.1 together with the circuit tube sizes and their wall thicknesses.

Table 1.2.1 Shaft Transfer Line system requirements and line sizes

	P (bar)		T	Flow Rate (g/s)		O.D.	Wall
Cryo. Circuits	Design	Nom.	(K)	Design	Nom.	(in)	(in)
4 K He supply	20	4	4.5	400	400	3	0.065
4 K He return	20	3.5	4.3	400	100	3	0.065
4 K gas He	10	1	4.0	400	300	4	0.065
20 K He supply	20	3	16.5	200	200	3	0.065
20 K He return	20	2	24	200	200	4	0.065
80 K liquid N_2	20	10	80	TBD	TBD	3	0.065
80 K gas N_2	10	1	80	TBD	TBD	4	0.065

1.3 General Description

The depth of the utility shaft which composes the majority of the shaft transfer line varies from sector to sector. The length of the horizontal section of the STL at surface also varies at a few sectors. The depth of the utility shaft from surface to the beam line and other pertinent parameters are listed in Table 1.3.1.

Table 1.3.1 Surface and beam altitudes

LOCATION	SURFACE ALTITUDE (m)	DEPTH TO BEAM LINE (m)	BEAM LINE ALTITUDE (m)	BEAM LINE REF. ALT. (m)
N15	233.17	74.06	159.11	75.96
N25	197.97	33.87	164.10	80.95
N35	208.03	57.92	150.11	66.96
N45	161.54	37.50	124.04	40.89
N55	140.21	41.45	98.76	15.61
N20	217.17	53.13	164.04	80.89
N30	207.26	48.00	159.26	76.11
N40	161.54	23.70	137.83	54.68
N50	151.64	41.21	110.43	27.28
EAST CLUSTER				
S15	150.88	66.48	84.40	1.25
S25	139.45	53.40	86.05	2.90
S35	139.54	27.04	102.50	19.35
S45	156.21	30.51	125.70	42.55
S55	169.16	24.99	144.17	61.02
S20	140.21	57.06	83.15	0.00
S30	145.54	52.76	92.78	9.63
S40	155.45	41.49	113.96	30.81
S50	163.83	27.61	136.22	53.07
WEST CLUSTER				

The shaft transfer line consists of seven cryogenic circuits enclosed in a common vacuum jacket, an insulation system, an internal suspension system, and an external suspension system. A cross section of the cryostat is presented in Figure 1.3.1.

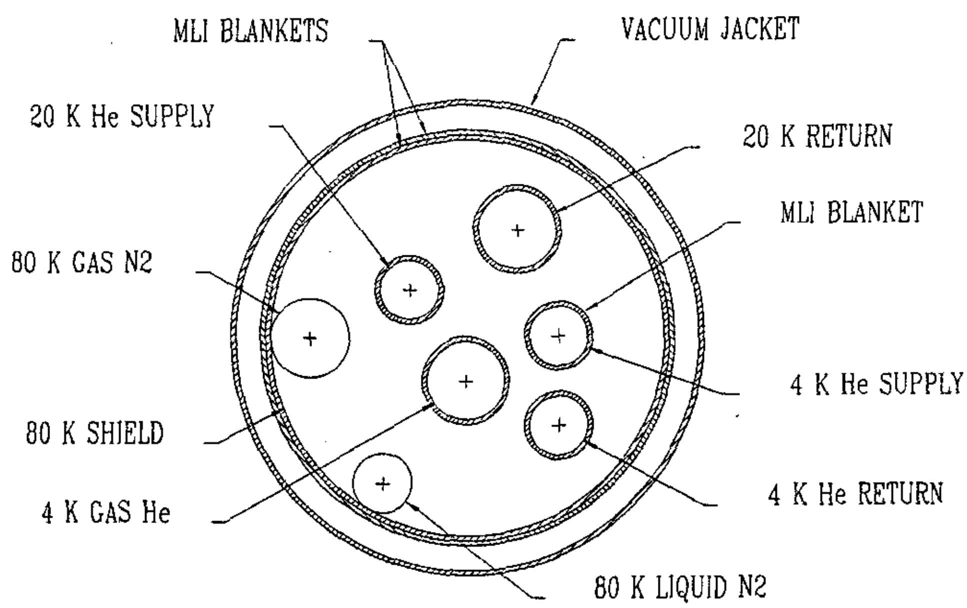
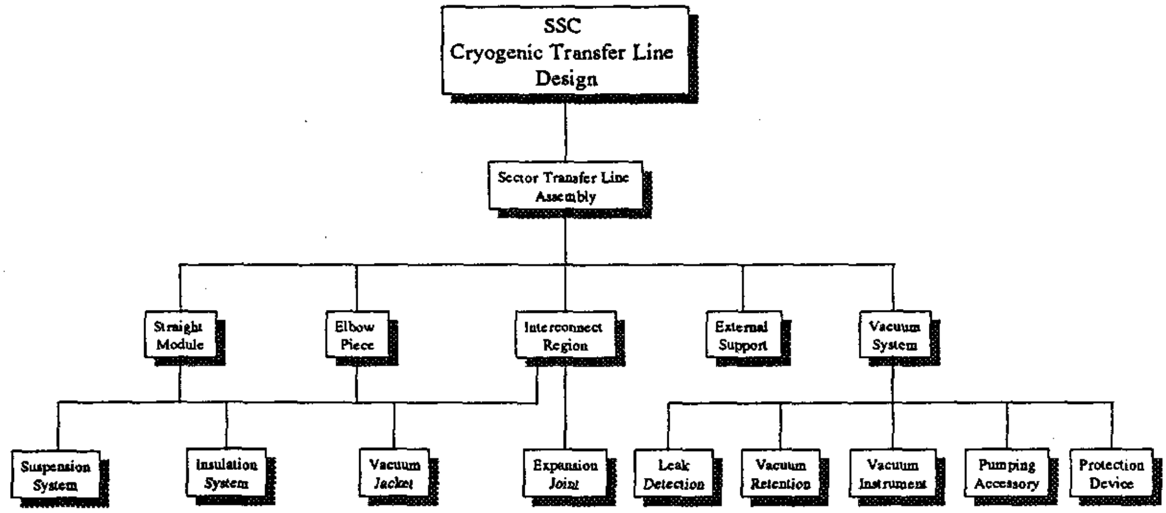


Figure 1.3.1 Cross section of shaft transfer line

Each STL is to be built in basic construction units (straight module, elbow piece, and make-up piece) and assembled on-site. The scope of the design task consists of stress and heat transfer analyses, mechanical design, vacuum design, as well as instrumentation. The outline is given in the following chart

TLCHART.PPT
3/18/93



Considering factors such as manufacturability, convenience in transport and handling, and economics, the maximum length of the straight module will be 40 feet (12 m). The size of the elbow piece is kept at minimum. The make-up piece basically is a section of the straight module with a variable length. It is used to meet the exact length requirement of each section of a STL. For heat leak and economics considerations, the seven cryogenic circuits share a common cryostat instead of residing in individual vacuum jacketed VJ) lines.

The thermal shield, covered by two MLI blankets, encloses all the circuit tubes and is soldered to the 80 K liquid tube at designated intervals to provide the required refrigeration. To reduce heat leak, each helium circuit tube is also covered by an MLI blanket. The cryogenic circuits, thermal shield, MLI system, and internal suspension system can be fabricated and assembled in a bundle before being slid into the vacuum jacket and secured at one end. Static and dynamic loads from the internal elements are transmitted to the vacuum jacket through the internal suspension system. To ensure proper function of the cryostat, the space enclosed by the vacuum jacket will be evacuated after the on-site final assembly. At a balance between cost and maintenance convenience, each shaft transfer line is a single vacuum unit. For vacuum maintenance and leakage diagnosis, a pumping port is provided at every interconnect region where two neighboring construction units are to be joined. Two pressure relieve devices are installed on each STL to protect the cryostat from being internally pressurized when a circuit leak occurs. A stainless steel vacuum barrier is attached to each end of a STL to isolate the vacuum space of the cryostat from neighboring equipment. Stainless steel bellows are used to accommodate thermal movement of each circuit tube. They are installed at every interconnect region.

An elbow piece completes a 90° bend. Mitered sections are used as shown in Figure 1.3.2.

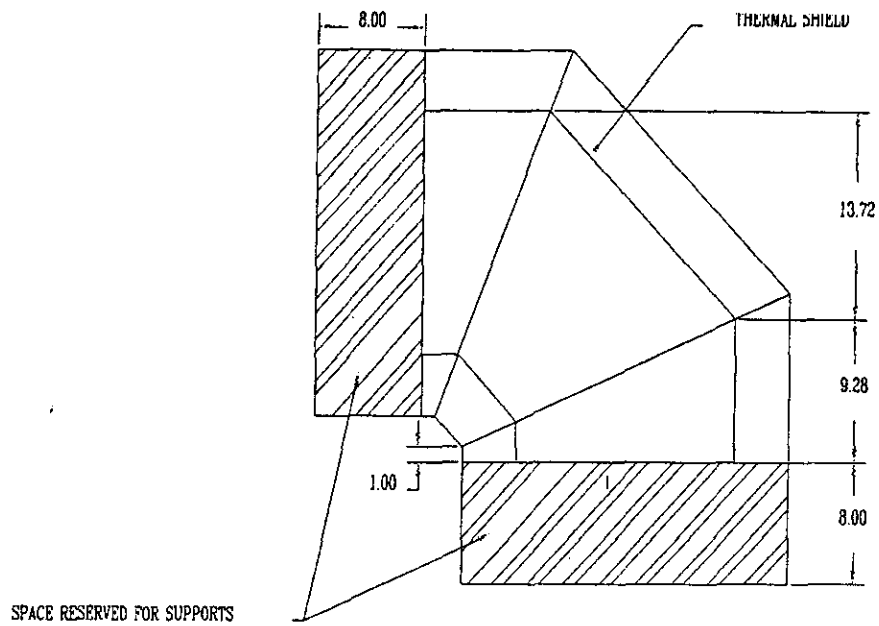


Figure 1.3.2 Cross section of elbow piece

The circuits tubes are bent at two locations within the cryostat of the elbow piece. Straight tube sections between the bends are parallel to the vacuum jacket. Such configuration offers better manufacturability for the thermal shield and MLI blankets. The mitered sections are sized in such a way that the middle sections can be slid in from either end at assembly without having to be cut in halves. The hatched areas designate the spaces reserved for the internal supports.

1.3.1 Design Requirements

Besides meeting the system functional requirements, the STL design has to meet certain strength and heat leak requirements. The internal suspension system is designed to withstand a 2g loading in all directions for transport. Part of the internal suspension system will experience dynamic loads. Loads to be considered include the following:

- static (2g)
- hydrostatic
- thermal

The static loads are summarized in Table 1.3.2

Table 1.3.2 Element weight of standard module

Element	Material lb/ft	Content lb/ft	Total lb/ft	Module lb
4 K supply	2.04	0.38	2.42	95.31
4 K return	2.04	0.38	2.42	95.31
4 K gas	2.73	0.09	2.82	111.14
4 K sum	6.81	0.86	7.67	301.77
20 K supply	2.04	0.38	2.42	95.31
20 K return	2.73	0.68	3.41	134.41
20 K sum	4.77	1.07	5.84	229.72
Sub total	11.58	1.93	13.50	531.50
80 K liquid	2.04	3.64	5.68	227.26
80 K gas	2.73	0.03	2.76	108.54
80 K sum	3.75	3.67	8.44	335.8
Sub total	15.33	5.6	21.94	867.3
MLI	0.75	N/A	0.75	29.65
Shield	9.74	N/A	9.74	383.46
Rad. support	35.27			176.35
Long. support				
Internal sum				
Vac. jacket	63.41	N/A	63.41	2496.46
Attachment				
Total				

Hydrostatic and hydrodynamic loads on each internal support of the elbow piece are listed in Table 1.3.3.

Table 1.3.3 Hydrostatic and hydrodynamic loads on each elbow support

	Static (lb)	Dynamic (lb)
4 K He supply	2078	0.045
4 K He return	2078	0.045
4 K gas He	1847	0.33
20 K He supply	2078	0.042
20 K He return	2078	0.042
80 K liquid N2	2078	1.538
80 K gas N2	1847	0.964
Total	14084	3

where the static load for each circuit is the product of design pressure and the inner cross-sectional area, and the dynamic load is calculated using

$$F = \dot{m}v(1-\cos\theta)$$

Since the turning angle θ = 90° for both elbow pieces, the above equation becomes

$$F = \frac{\dot{m}^2}{\rho A}$$

where ρ and A are density and cross-sectional area respectively. The hydrostatic force is calculated using the design pressure

$$F = pA$$

This load is the major consideration of the internal and external suspension systems design. It is transmitted to the vacuum jacket through the internal supports in the elbow piece, and to the concrete wall or foundation through the external supports for the elbow piece. Other loads appear to be insignificant in magnitude and can be covered by the reserved safety margin. A safety factor of two for material strength is used for the loads considering that the most severe condition in both cases is temporary. The hydrostatic loads are calculated based on the design pressure instead of the nominal pressure.

Considering the failure mode when the internal suspension system in one vertically installed module collapses, the internal suspension system of the module above it should remain intact.

1.3.2 Heat Leak Budgets

Due to the variation of the utility shaft depth, the heat leak budgets for the STL are allocated on a unit length basis as shown in Table 1.3.4.

Table 1.3.4 Transfer line heat leak budgets

Heat Leak Budget W/ft (W/m)		
4 K	20 K	80 K
0.03 (0.0984)	0.1 (0.328)	1.2 (3.94)

Heat transfer modes contributing to the total heat leaks include thermal radiation, residual gas conduction, solid conduction through MLI blankets, and solid conduction through the internal suspension system. The heat transfer modes are analyzed individually and then superimposed. The heat leak budget per unit length of transfer line is based on the heat leaks into the longest shaft transfer line at N15 site divided by its length.

The total heat leaks for the transfer line systems allocated to the sectors are summarized in Table 1.3.5.

Table 1.3.5 Transfer line system heat leak budget summary

Location	Heat Leak (W)		
(Sector)	4 K	20 K	80 K
N15	8.1	27	324
N25	4.1	13.8	166
N35	6.5	21.7	260
N45	4.5	15	180
N55	4.9	16.3	196
S15	7.4	24.5	294
S25	6.1	20.2	243
S35	3.5	11.6	139
S45	3.8	12.7	153
S55	3.3	10.9	131

1.3.3 Safety Devices

Pressure relief devices are required to protect the vacuum jacket from potential damage due to excessive internal pressure in the vacuum space of the cryostat which can be caused by leakage from any cryogenic circuit.

1.3.4 Maintenance

A tree structure of pumping/leak detection port is provided at every interconnect region for easy maintenance. The cryostat is designed in such a way that it can maintain a vacuum level of 1.0×10^{-6} torr at a helium leakage rate less than 10^{-6} std cm^{-3}/s. The port provides the access for leak detection and diagnosis. The leakage location can be determined by analyzing the molecule concentration in the cryostat space (Jim Briggs, *1992*), or by measuring the pressure gradient while pumping (Kimo Welch, *1993*).

1.3.5 Interface

The STL interfaces with the SDB and CCB. Due to the bends at the top and bottom of the utility shaft, the pattern of the internal circuit tubes varies from the vertical section to the horizontal section. To illustrate this clocking phenomenon, define a coordinate system for the vertical section by choosing *Z* axis vertically up, coinciding the center line of the cryostat, *X* axis parallel to the tangent of the utility shaft wall at the installed position, and *Y* axis normal to and away from the utility shaft wall. For the horizontal sections, the *Z* axis is a continuation of that defined for the vertical section, following the center line of the cryostat, the *Y* axis is defined as vertically up, and *X* axis is horizontal and is determined using *Y* and *Z* axes following the right hand rule. The coordinate system transformation for an arbitrary bend is schematically shown in Figure 1.3.3.

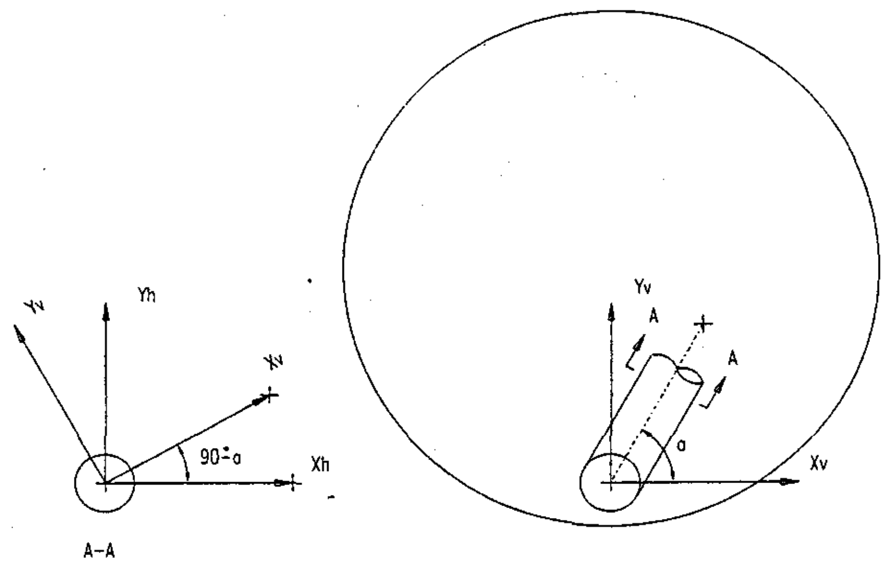


Figure 1.3.3. Pattern clocking due to bend (pattern.dxf).

1.3.6 Pressure Drops

The pressure drops through the circuit lines are computed based on the nominal flow rates. A computer program (TLDP) is developed for such calculation and the results are graphically presented in Figure 1.3.8.

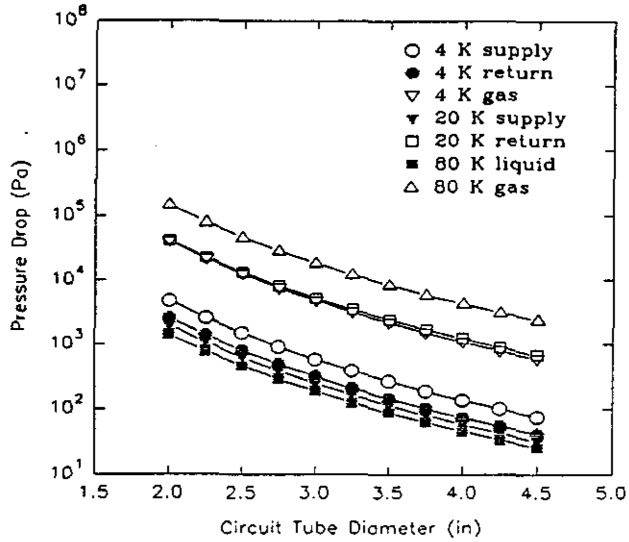


Figure 1.3.8. Pressure drops through cryogenic circuits (tldp.dxf).

1.3.7 Assembly, Transport, and Handling

Temporary covers are required to protect the interior of the cryostat from damage and contamination at both sides of the modules and elbow pieces during transportation. Lugs for handling are to be designed, manufactured and installed on the vacuum jacket before a module can be shipped. Appropriate procedures are to be developed for proper transportation, handling, and assembly.

To estimate the maximum length of a single construction unit that can be lowered down into the tunnel through the utility shaft, a sketch is shown in Figure 1.3.4 to illustrate the space constraint.

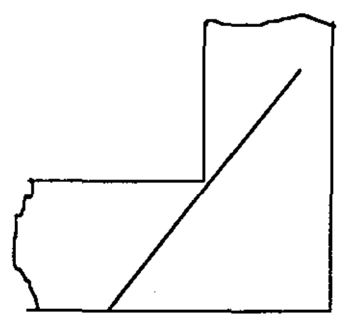


Figure 1.3.4. Space constraint for transfer line module to be lowered into tunnel through utility shaft.

Notice that the following relation has to be obeyed

$$L \leq \frac{D}{\sin\alpha} + \frac{H}{\cos\alpha}$$

To reach the maximum, take the first derivative of L with respect to α and let it be zero, getting

$$\tan\alpha = \sqrt[3]{\frac{D}{H}}$$

Use the drop zone diameter of the utility shaft (D = 14') and the height of the hammer head cryogenic chamber H = 20'), we get $\alpha = 41.602°$. This angle gives a maximum length of L = 47.83 ft.

2. INTERNAL SUSPENSION SYSTEM

2.1 Straight Module Internal Suspension System

The straight module internal suspension system holds the circuit tubes, the thermal shield, and the MLI blankets in place and transmits the loads to the vacuum jacket. It consists of one longitudinal and four radial supports. The longitudinal support is located at one end of the module (the upper end when the module is installed vertically). This support is anchored to the vacuum jacket. It bears all the longitudinal loads from the internal elements. Each circuit tube is welded to a stainless steel collar which in turn is bolted to the longitudinal support. Fastening methods relying on friction should be avoided as they will not produce the required force to withstand the loads.

The radial supports are installed in such a way that one of them is located at the opposite end to the longitudinal support, and the rest spaced at even intervals in between. These supports restrict the radial movement of the circuit tubes while allowing their longitudinal movement. Each radial support assembly is secured to the 80 K circuit tubes. During the cool-down and warm-up periods, the radial support assemblies follow the thermal movement of the 80 K liquid nitrogen circuit tube. Evidently, the largest travel occurs at the last radial support assembly (at the free end) of a module. Three caster modules (or equivalent sliding mechanisms) are attached to the radial support assembly at the warm end. The caster modules can roll longitudinally along the inner surface of the vacuum jacket wall. The 4 K and 20 K circuit tubes can slide longitudinally in the radial assembly, An isometric view of the straight module is shown in Figure 2.1.1.

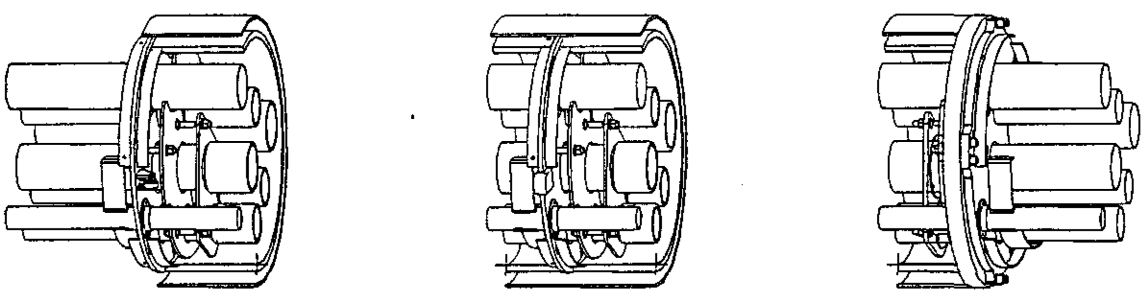


Figure 2.1.1 Isometric view of transfer line straight module.

2.1.1 Longitudinal Spacing between Supports

For transport purpose, the conventional requirement is to keep the natural frequency of the equipment to be shipped above 30 Hz. The natural frequency f_n of the tube can be calculated using the equation

$$f_n = C_n \sqrt{\frac{gEI}{wl^4}}$$

where C_n-------Coefficient depending on boundary conditions and mode number
g---------Gravitational acceleration (in/s^2)
E-------- Modulus of elasticity of pipe material (psi)
I--------- Moment of inertia of pipe (in^4)
w-------- Weight per linear unit length of pipe (lb/in)
l--------- Spacing (in)

This equation is coded into a computer program (span.for) to calculate the spacing for each circuit tube and the vacuum jacket. The results are summarized in Table 2.1.1.

Table 2.1.1 Spacing for internal supports based on a natural frequency of 30 Hz

Tube Element	$C_n = 1.56$	$C_n = 6.28$	$C_n = 14.1$
3" O.D. × 0.065" wall	2.524 m	5.064 m	7.588 m
4" O.D. × 0.065" wall	2.9 22 m	5.863 m	8.785 m
24" O.D. × 0.25" wall	7.179 m	14.40 m	21.58 m

Under operating condition, the spacing between supports can be calculated by the formula

$$l = \sqrt{\frac{10ZS}{w}} \; l = \sqrt{\frac{10ZS}{w}}$$

where

$$Z = \frac{\pi}{32}\frac{D^4 - d^4}{D}$$

is the section modulus of tube (in^3), S allowable weight stress (psi), and w weight per linear length of tube (lb/in). Generally, this equation allows a larger spacing between supports.

The EJMA standards recommend four times and fourteen times pipe O.D. for the first and second pipe guide respectively, and the following equation for the maximum spacing between intermediate guide (Eqn B-9)

$$L = 0.131\sqrt{\frac{EI}{pa \pm fe_x}}$$

Where L maximum intermediate guide space, (ft)
E modulus of elasticity of pipe material, (psi)
I moment of inertia of pipe, (in^4)
p design pressure, (psig)
a bellows effective area, (in^2)
f bellows initial spring rate per convolution, (lb/in/conv)
e_x axial stroke of bellows per convolution, (in/conv.)

The positive and negative signs are for compression and extension use of the bellows respectively. Normally, this equation gives a span longer than that evaluated based on the natural frequency criterion. The current design does not meet the requirement on the second guide.

2.1.2 Plate Thickness

The thickness of each composite or stainless plate is determined based on the magnitude and distribution of the loads applied to it. A computer program (CENTER) is developed to calculate the load distribution in each plate. This program is also used to strategically locate the standoff rods such that the strength requirements for the plates are minimized. Finite element schemes are used to determine the stress level. A commercial software package from Algor is used for the analysis, and the results from CENTER are imposed on the finite element model as boundary conditions. Two design options using composite material and stainless steel are evaluated. The plate thickness for the composite design option is tabulated in Table 2.1.2.

Table 2.1.2 Plate thickness of supports for composite design option.

Support	4 K (in/mm)	20 K (in/mm)	80 K (in/mm)
Radial	0.25/6.35	0.25/6.35	0.375/9.525
Longitudinal	0.325/6.35	0.5/12.7	0.75/19.05
Elbow	0.75/19.05	1/25.4	1/25.4

The results of the analysis and file names for the stainless steel design option are listed in Table 2.1.3.

Table 2.1.3 Stress level and heat leak for stainless steel longitudinal and elbow supports.

	Longitudinal Support			Elbow Support		
	4 K	20 K	80 K	4 K	20 K	80 K
Thickness (in/mm)	3/16 (4.76)	1/4 (6.35)	3/8 (9.53)	1/2 (12.7)	5/8 (15.9)	5/8 (15.9)
Max. Stress (MPa)	258	209	253	334	357	266
Heat Leak (W)	0.06	1.5	28	0.06	1.5	42
File Name	SS4L	SS20L	SS80L	SS4E	SS20E	SS80E

Detailed results of stress analysis for the composite design option are discussed in reference?. The stainless steel design option uses the same radial support as the composite design option.

2.1.3 Heat Transfer Analysis

Heat transfer analysis for stainless steel design option is based on the assumption that the temperature gradients in the plates are negligible. The total thermal resistance is then due to the standoff rods and the composite washers. The following equations are used to calculate the resistances for the standoff rods and washers respectively

$$R_{rod} = \frac{\Delta T}{Q} = \frac{L}{A} \Delta T \frac{1}{\int kdT}$$

$$R_{washer} = \frac{t}{Ak}$$

where k, A, and L denote thermal conductivity, cross-sectional area, and length respectively. The total heat leak through conduction is then calculated using

$$Q = \frac{\Delta T}{R_{rod} + R_{washer}}$$

For the composite design option, heat transfer analysis is conducted on each support assembly (radial, longitudinal, and elbow piece) using Algor's finite element package. Detailed procedures and results are given in Zhang (1993).

2.1.4 Balance of Radial Support

A radial support consists of three plates. Since the support assembly is secured to the 80 K circuit tubes, a bending moment results when the support is applied to a horizontal section of transfer line. To eliminate this bending moment, the roller modules should be located in such a way that the support assembly is balanced. To demonstrate this idea, take the roller axis as the pivoting point about which the total moment should be zero. The location of the roller is then determined using the equation

$$L_{80K} = \frac{L_{4K} \times w_{4K} + L_{20K} \times w_{20K}}{w_{80K}}$$

where L is the longitudinal distance between the roller axis and the plate, and w is the weight that the plate bears.

2.1.5 Installation of MLI Blankets

The internal support assemblies (both longitudinal and radial) are equipped with stainless steel brackets to support the MLI blankets. The blankets are secured to the brackets using barbed Snap-On type nylon fasteners at designated locations to reduce heat leaks.

2.1.6 Standoff Rods

A group of three standoff rods are used to link the 4 and 20 K plates. There are mainly two purposes for using the standoff rods: a. the rods redistribute the loads on the 20 K plate from the 4 K circuit tubes, reducing the strength requirement on the 20 K plate; b. since the rods are designed primarily to bear tensile loads, the tensile strength of stainless steel can be utilized to reduce the cross-sectional area of the rods and hence reduce the heat leak from the 20 K circuit to the 4 K circuit. Another group of three standoff rods are used to link the 20 K plate to the 80 K plate based on the same design principle. The diameter of the rods are determined based on the most severe loading condition that occurs at the internal supports for the elbow piece.

For the horizontal sections, the rods will experience a bending moment. The stress level due to such load can be estimated using

$$\sigma = \frac{M}{I/C} = \frac{(304.7 \times 2/6) \times (2 + 1/4/2 + 3/8/2)}{\pi R^4/4/R} = 45{,}353 \text{ psi}$$

where R = 3/16" has been used. This calculation is based on the assumption that one rod is supporting the load alone. The bending stress concentration factor is determined as 1.3 from Figure 6-15 of Popov 1990.

Evidently, the rods used on the elbow support require a larger diameter (1/2"). All rods share the same design for manufacturing convenience except the length of the threaded ends, which varies from plate to plate to meet the dimension requirements.

2.2 Elbow Piece Internal Suspension System

The internal suspension system for the elbow piece is different from that of the straight-module. It consists of only two supports, one at each end of the elbow piece. Both supports are anchored to the vacuum jacket. Due to the 90° bend, each support will experience both hydrostatic and hydrodynamic loads during operation. For this reason, no expansion joint is used within an elbow piece. The thermal movements of the circuit tubes have to be accommodated by their own flexures, which adds additional loads to the supports. Depending on the pattern orientation of the circuit tubes in each individual elbow piece, the thermal stress may be partially or totally relieved due to its self-limiting nature when the supports deform at design pressures. The thermal stress in each circuit tube is analyzed using Algor's PipePlus under the file name "ELBOWL". The hydrostatic load distribution is calculated using a computer program (CENT).

2.3 Heat Leaks through Internal Suspension System

Substantial effort is required to reduce the heat leaks into the cryogenic circuits through the internal suspension system while maintaining its strength. Table 2.3.1 lists the heat leaks into the cryogenic circuits through the elements of the internal suspension system of the composite design option.

Table 2.3.1 Heat leaks into cryogenic circuits through supports and vacuum barrier.

Support/barrier	Heat Leak (W)		
	4 K	20 K	80 K
Radial	0.038	0.39	2.6
Longitudinal	0.047	0.62	6.3
Elbow	0.062	0.89	9.1
Barrier	0.023	0.85	10.7

Such low heat leaks are due primarily to the design of the internal suspension system. Heat leaks through the internal supports are computed using Algor's heat transfer analyzer. Details are given in reference?. Heat leaks through vacuum barrier is evaluated using an in-house developed computer program HB.

2.3.1 Sizing for Copper Straps on Supports

Copper straps are used to establish desired temperature boundary conditions on each support assembly. Generally, the standoff rods are to be maintained at 20 and 80 K on the 20 and 80 K plates sides respectively. To achieve this, thermal shorting straps are used to anchor the standoff rods between the 4 and 20 K plates to the 20 K circuit tubes on the 20 K side. Similarly, the standoff rods between 20 and 80 K plates are anchored to the 80 K circuit tubes on the 80 K side. To size the straps, consider the equation

$$Q = tWk\frac{\Delta T}{L}$$

where t, W, and L are the thickness, width, and length of the strap respectively, k the thermal conductivity, Q heat leak to be intercepted, and T temperature. Using k_{80K}=570 W/m-K, k_{20K}=1050 W/m-K, and Q = const. for each individual rod, ΔT = 2 K, and t = 0.125", a relationship between the width and length can be established

$$W = CL$$

with

$$C = \frac{Q}{tk\Delta T}$$

Values of Q to be used should be based on the elbow piece internal support design. The width W is then determined accordingly depending on the length L of the strap which is measured after the layout.

3. CRYOSTAT

3.1 Thermal Shield and MLI System

The cryostat serves for the purpose of reducing heat leaks into the cryogenic circuits. From the cryogenic system, refrigeration for the thermal protection of the cryostat is available at temperature levels of 20 and 80 K. Considering the trade-offs in increased structural design complexity and reduced reliability, only one thermal shield at 80 K is adopted. The shield is made of gauge 19 copper sheet which is rolled into a cylinder and soldered to the 80 K liquid circuit tube.

3.1.1 Thermal Shield

The design of the thermal shield is primarily based on the consideration of two factors: the strength to support the MLI blankets, and the capability to limit the temperature variation in a shield under a predetermined level. The shield thickness required based on the buckling criterion is determined using the equation

$$t = \left(\frac{P(1-\nu^2)}{2E} \right)^{1/3} D_o = \left(\frac{0.0038709(1-0.3^2)}{2 \times 1.1 \times 10^7} \right)^{1/3} \times 19.764 = 0.0107321'' = 0.273 \text{ mm}$$

where the normal pressure on the shield surface is calculated assuming that the MLI is evenly distributed over the upper half of the shield (two blankets of 32 alternating layers of mylar and spacer material):

$$P = 2 \times 2 \times 1.5 lb/m^2 = \frac{6}{10.764} lb/ft^2 = 0.0038709 \text{ psi}$$

The heat transfer characteristics of the shield is modeled using Algor's heat transfer analyzer. The finite element model is under the file name "TSHIELD". The thermal conductivity of copper at 80 K k = 500 W/m-K and a heat flux q = 0.66 W/m2 are used. The modeled sheet has the dimensions 1.32 m x 2.84 m x 0.001 m. To simulate the heat flux into the shield, a volumetric energy generation term q/V = 660 W/m3 is used based on the thickness of 1 mm. The simulated temperature distribution in the shield is shown in Figure 3.1.1.

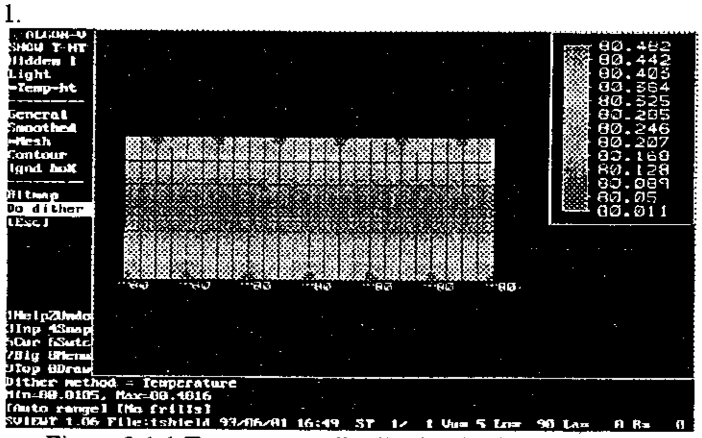


Figure 3.1.1 Temperature distribution in thermal shield.

It appears that for the designed heat flux, the copper sheet has a thickness which is sufficient to dissipate heat such that the maximum temperature rise in the shield will be under 1 K. Finally, copper sheet (thickness = 1 mm or 0.039") is selected as the construction material of the shield.

Spacing between Solder Joints

The spacing between solder joints is based on the idea that the local longitudinal temperature variation should be less or equal to that of circumferential. The larger of the shield arc is approximately 53", therefore the spacing should be less or equal to that. From structural view point, the spacing is determined as 20" with a solder joint length of 6". Fifty-six percent silver hard solder may be used for the soldering.

Thermal Movement

The thermal shield is attached to the 80 K circuit tubes by soldering. Thermal stress occurs in the shield as the system is cooled down. Since copper has a larger thermal contraction coefficient than stainless steel, the stress is tensile. For ΔT = 300 K- 80 K, $\Delta L_{copper}/L = 3.09 \times 10^{-3}$ and $\Delta L_{s.s.}/L = 2.9 \times 10^{-3}$. These values lead to a tensile stress in the shield

$$\varepsilon = \frac{\Delta L_{copper} - \Delta L_{s.s.}}{L} = (3.09 - 2.9) \times 10^{-4} = 1.9 \times 10^{-4}$$

Use $E = 15.6 \times 10^6$ psi for copper, the maximum tensile stress in the shield is calculated as

$$\sigma = \varepsilon E = 15.6 \times 10^6 \times 1.9 \times 10^{-4} = 2{,}964 \text{ psi}$$

There is another scenario that may cause thermal stress in the shield. During various operating modes, one 80 K circuit tube may be still warm while the other is at 80 K. The concern is the structural integrity of the shield and the solder joints under such adverse situations. This time, the shield on the cold tube side is compressed. Theoretical prediction for such situation appears to be less reliable. Therefore, an experiment was set up to verify the behavior of the shield and solder joints assembly. Two pieces of stainless steel tubes and one copper sheet are used for the experiment. The copper sheet has a dimension of 2 m × 0.266 m. It is soldered to the 2 meter long tubes. One of the tubes is then filled with liquid nitrogen while the other remains at ambient temperature. It was observed that as one tube is cooled down, the sheet on the cold side gradually buckled between the solder joints.

3.1.2 MLI Blanket

Two MLI blankets are used over the thermal shield. Each blanket has 32 layers of alternating double-sided aluminized mylar and spunbonded polyester spacer. It is made by sewing the layers together along the two longitudinal edges with Velcro strips. Sufficient escaping path must be provided for molecules entrapped in the blanket layers to ease the vacuum roughing. An MLI blanket of 20 layers is applied to each helium circuit tube to further reduce heat leak. Heat leak analysis through the MLI blankets is estimated using a computer program LEAK which produces the anticipated heat leaks into 4, 20, and 80 K circuits for given cryostat geometry, blanket layers and vacuum level. Factors considered include radiation, solid conduction, and residual gas conduction.

To reduce heat leaks into the helium circuits through the internal suspension system, thermal shorting straps are required to maintain temperature boundary conditions of 20 and 80 K at designated locations on both longitudinal and radial internal support assemblies. The straps are made of copper and sized sufficiently for the intended heat leak interception. The maximum allowable temperature drop through one strap will be less than 2 K. Detailed calculations are given in 2.3.1.

3.2 Vacuum System

Each shaft transfer line is a single vacuum unit. It is isolated from the neighboring equipment by using two vacuum barriers at the ends. A vacuum pumping/leak detection port is provided at each interconnect region. The design vacuum level of the cryostat is 1.0×10^{-6} torr at the inner surface of the vacuum jacket wall. This vacuum level should be maintained even at the presence of a minor leak at a rate less than 10^{-6} atm·cm^3/s.[1]

Outgassing Rates

All construction materials exposed to the vacuum space will outgas during roughing and normal operation. The major constituent of the outgassing is water vapor. The double aluminized mylar contributes the most to the total outgassing. The net effect is amplified as the MLI blankets consist of a large number of alternating layers of mylar and spacer material. Using the experimental data collected at Brookhaven National Laboratory, we will have the following

Table 3.2.1 Water vapor content in MLI materials

	Total Outgassed Water	
Material	per unit area	per straight module (12 m)
Reemay Spunbonded Polyester	4.0×10^{-6} g/cm^2	460 g
Double Aluminized Mylar	1.23×10^{-5} g/cm^2	1413 g

Data collected from other reference are summarized in Table 3.2.2.

[1]The Sensitive Leak Test required by ASME B31.3 dictates a sensitivity not less than 10^{-3} atm·cm^3/s under test conditions (see p.84).

Table 3.2.2 Outgassing rates of STL construction materials

Material	Condition	Outgassing rate (torr· l/s·cm^2)
Copper	As received	1.0×10^{-9}
Mylar	Degreased	1.5×10^{-7}
Stainless steel	Degreased	2.5×10^{-10}
Steel, mild	Clean, slightly rusty	3.0×10^{-8}

3.2.1 Cryocondensation

Cryocondensation (cryopumping) essentially involves two processes: solidification and adsorption of residual gas particles on a surface at cryogenic temperature. For both processes, the bonding between the cryosurface and the gas molecules is by means of van der Waals' forces. In the STL cryostat, the thermal shield and the 80 K circuit tubes are exposed to the vacuum space, and both will be cryopumping after the system cool-down. For the evaluation of cryopumping capacity purpose, a specific pumping speed (pumping speed per unit area) S/A = 14 l/s-cm^2 can be used for the 80 K surfaces. This will provide sufficient cryopumping power for the condensable gas constituents which enter the cryostat space due to the outgassing of the surfaces in the cryostat. Outgassing is a continuous process in the cryostat after the cryostat is rough-pumped and cooled down. Surfaces that should be included for the outgassing consideration primarily include the inner surface of the vacuum jacket, surfaces of the MLI blankets, and surfaces of the internal suspension assembly.

Ultimate Achievable Vacuum Level

The ultimate achievable vacuum level from cryocondensation can be estimated using the formula (Leybold, 1992)

$$P_{ult} = P_s(T_c)\sqrt{\frac{T_w}{T_c}\frac{f_w}{f_c}}$$

where P_S is the saturation pressure of the pumped gases at the cold surface temperature T_C, T_W is the temperature at the inner wall of the vacuum jacket, and f_C, f_W are the sticking coefficients at T_C and T_W respectively (Roth, 1990).

3.2.2 Cryosorption

Cryosorption is a physical adsorption process which also relies on van der Waal's forces. The equilibrium pressure of adsorbed gas particles is far lower than the corresponding saturation vapor pressure. Particles of the gas constituents which are difficult to condense (helium, hydrogen, and neon with condensation temperatures at 0.3, 2.5 and 6 K respectively, Haeffer, 1989.) can be adsorbed in sub-saturated conditions. The binding energy between gas particle and adsorbing particle is considerably greater than that between gas particles them selves. Consequently, the equilibrium pressure of gas particles is far lower than the corresponding saturation vapor pressure. Activated charcoal can be used as the adsorbent in the getter. The getter has an enclosure (shroud) to block the condensable gas especially water vapor molecules which otherwise will saturate the getters in a rather short period of time. This enclosure will also serve as a thermal shield to prevent direct radiative thermal communication between the getter adsorbent and other warmer surfaces in the cryostat. Sufficient conductance between the vacuum space of the cryostat and the adsorbent material is provided for initial desorption of water vapor before the cool-down and for the adsorption of helium molecules during normal operation. The getter module is both mechanically and thermally attached to the 4 K gas helium circuit to obtain the required mechanical support and refrigeration. It can be located either between the 4 and 20 K plates of the radial support at one end of the module cryostat, or in each interconnect region depending on its final size. The quantity of charcoal to be used in each getter is calculated based on the assumption that the average thermal cycle of the collider is one year, multiplied by a safety factor of two. The getters are to be regenerated every time the system is warmed up.

Material Specification

The frame of the getter module is formed out of 16 gauge stainless steel sheet, the wire cloth is 40 mesh with a 0.01" wire diameter and an opening width of 0.015". The open area is 36% of total surface area. The adsorbent is Calgon activated coconut charcoal type PCB 12 × 30.

Charcoal Quantity Calculation

The helium leak rate can be considered as undetectable if it is below 1E-9 scc/s at standard condition. Using a safety factor of 1000, the total leak rate is specified as

$$Q = 1E\text{-}6 \text{ scc/s} = 7.6 \text{ E-7 torr} \cdot \text{l/s}$$

at standard temperature and pressure, which gives a total leak per year at

$$Q = 31.536 \text{ scc/yr} = 23.967 \text{ torr} \cdot \text{l/yr}$$

According to Hseuh and Halama (1979), a sorbing capacity ~ 8 torr $\cdot$l/cm^2 of He on charcoal at 4.2 K can be obtained after charcoal panel is evacuated to 1 E-5 torr (N_2 equivalent) for couple days. Using this capacity, we get the required substrate area for continued operation of a year

$$A = 23.967 / 8 = 2.996 \text{ cm}^2$$

Using the surface charcoal density ~ 0.1 g/cm^2, the required charcoal quantity becomes

$$m = 0.1 \times 2.996 = 0.2996 \text{ g}$$

For an apparent density $\rho = 0.44$ g/cm^3, the required charcoal volume is

$$V = 0.3 \times 0.44 = 0.132 \text{ cm}^3$$

In another literature, Hseuh et. al (1982) proposed a surface coverage of 1 scc/cm^2 which leads to a mass quantity

$$m = 31.536 \text{ scc} / 1 \text{ scc/cm}^2 \times 0.1 \text{ g/cm}^2 = 3.1536 \text{ g}$$

Then the required charcoal volume becomes

$$V = 3.1536 / 0.44 = 7.167 \text{ cm}^3$$

Leaks into the vacuum space are normal classified into two types: real and virtual. The real leak represents gas influx into the vacuum space through pores in either the vacuum jacket or in the inner circuit tubes, while a virtual leak refers to outgassing of entrapped gas particles from solid surfaces within the cryostat. The leak rate of a real leak depends on the pore size. It has been pointed out by Chambers et al that the leak rate decreases with increase of temperature for viscous flow, but increases with temperature for molecular flow; and furthermore, both requires a minimum hole size of at least about 10 molecular diameters. According to Hseuh[3], a factor of 100 has been used by Brookhaven engineers for a leakage increase when the tube is cooled down to 4 K. This calculation is based on the assumed total leak rate which includes the cooling effect. The desorbing temperature threshold is believed to be in the range 18-20 K.

Initially, after the transfer line vacuum space is sealed off and rough-pumped, hot air stream (400 K) should be run through the 4 K gas helium tube to heat the getter in order to get rid of the water vapor molecules initially deposited to it under ambient conditions.

3.2.3 Vacuum Barrier

Each transfer line is an independent vacuum unit. At the interfaces, vacuum barriers are installed on neighboring equipment. After final installation, these two vacuum barriers will isolate the transfer line vacuum space. Temporary vacuum breaks are needed for protection and leak checking. Originally, a few types of vacuum breaks are designed or evaluated. Two examples are discussed below.

Concentric Reentrant Shell Design

The vacuum barrier is a stainless steel structure which isolates the end of the transfer line from the neighboring equipment (see Figure 3.2.1).

Figure 3.2.1 Shaft transfer line vacuum barrier

It primarily consists of three sets of concentric shells and plates, each for the group of circuit tubes at the same temperature (4 , 20, and 80 K). The shells are corrugated to increase their strength against buckling. The length of the shells is around 300 mm to reduce heat leak into the cryogenic circuits through solid conduction. The circuit tubes are welded to the plates. A computer program HS is developed to estimate the stress and buckling criteria for the vacuum barrier plates and shells. The heat leaks into the cryogenic circuit through the vacuum barrier in solid conduction is calculated by another program HB.

Individual Vacuum Bellows Design

Individual vacuum bellows can be used for each circuit tube at the ends of the STL to break the vacuum. This design option offers a better circuit tube pattern which allows the use of automatic welding machine on every circuit tube. The 80 K tubes can be separated further from each other, resulting much better load distribution and heat transfer characteristics. From economics view point, this design costs less than 10 percent of the barrier design. The drawbacks of this approach are a higher heat leak into the 4 K circuits (0.45 W compared to 0.023 W), and a slightly higher complexity in a section of thermal shield and MLI system near the vacuum bellows.

3.2.4 Vacuum Jacket

Wall Thickness

Per 304.1.3 of ASME B31.3, the wall thickness of the vacuum jacket is calculated based on the equation given in UG-28 of ASME B&PV Code Section VIII, Division I. Assume t = 0.23", then for D_o/t = 104 and L/D_o = 20, factor A is determined from Fig. 5-UGO-28.0 as 0.00011. Since this value falls to the left of the curves in Fig. 5-UGS-28.1, the equation

$$P_a = \frac{2AE}{3(D_o/t)}$$

is used yielding a maximum allowable external working pressure of 19.7 psig. The assumed thickness therefore can be the pressure thickness which should be augmented by a mechanical allowance factor c. The elbow piece consists of mitered bends. The thickness requirement for the mitered sections follows 304.2.3 of ASME B31.3 and allows higher external pressure. The 24" IPS schedule 10 (71.18 lb/ft, 94.35 kg/m, wall thickness = 0.25") carbon steel pipe has been selected as the construction material.

Thermal Movement

For a generic site, the maximum temperature variation is ΔT = 50 K according to document from Conventional Construction Division. Consider a transfer line as a whole after the final assembly, the induced thermal stress will be due to the expansion differential between the vacuum jacket and the concrete wall to which the transfer line is fastened. Using thermal expansion coefficients of 10.8×10^{-6}/K and 11.7×10^{-6}/K for concrete and carbon steel respectively, the strain in the vacuum jacket will be $\varepsilon = \Delta L/L = \Delta T(11.7-10.8) \times 10^{-6} = 4.5 \times 10^{-5}$. From Hook's law, the stress becomes $\sigma = \varepsilon E$ = 1350 psi when E = 30×10^6 psi is used. This kind of stress level is manageable without use of expansion joint. However, certain flexibility is required for the external suspension system. To verify this, calculate the force acting on an external support which is anchored to the utility shaft rigidly: $F = 1350 \times \pi (24^2-23.5^2) / 4$ = 25,182 lb. The total elongation of the vacuum jacket for the deepest shaft is in the order of $\Delta L = 4.5 \times 10^{-5} \times 74 = 0.00333$ m.

External Attachment

Lugs are to be attached to the vacuum jacket for handling and securing the transfer line to the external supports. Lugs (two) at each location are supposed to bear the total weight of a straight module (4000 lb). A sketch of the attachment for the external support is shown in Figure 3.2.2.

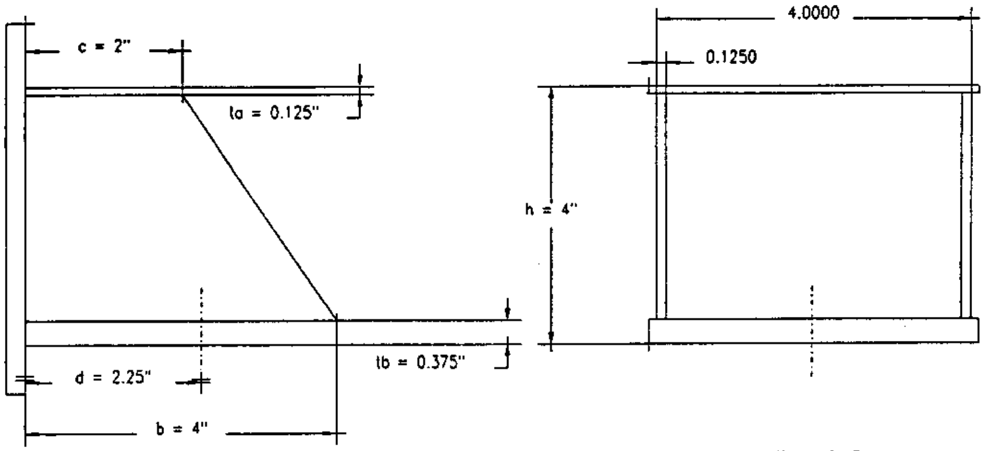


Figure 3.2.2 Vacuum jacket attachment for external support (lug.dxf)

Take S_a = 15,000 psi as the allowable stress for both vacuum jacket and lug material, we get

a. Base Plate

Bearing pressure P = 2000/4/3.5 = 145 psi. From the equation $\sigma = \beta P b^2 / t^2$, the thickness of the plate can be derived as

$$t = \sqrt{\frac{\beta P b^2}{\sigma}} = \sqrt{\frac{1 \times 145 \times 3.5^2}{15,000}} = 0.344"$$

b. Top Bar Plate

$$t_a = 0.75 \frac{Fda}{S_b c^2 h} = \frac{0.75 \times 2000 \times 2.25 \times 4}{15000 \times 2^2 \times 3.5} = 0.0643"$$

c. Gusset Plate

$$t_g = \frac{F(3d - b)}{S_a b^2 \sin^2 \alpha} = \frac{2000(3 \times 2.25 - 3.5)}{15000 \times 3.5^2 \times \sin^2 63.43^\circ} = 0.0442"$$

Stress in jacket (shell)

$$\sigma_b = C_{Lt} \frac{M_L}{t^2 r \beta} = 0.25 \frac{2000 \times 2.25}{0.188^2 \times 10 \times 0.2} = 15,915 psi$$

where the stress factor $C_{Lt} = 0.25$ is determined from Fig. 7.9 using $\gamma = r/t$ = 10/0.188 = 53 and $\beta = c/r$ = 2/10 = 0.2; with $c = (h \times a)^{0.5}/2$ = 2. Check results:

1. Resisting area

A_r = 2 × 1/8 × 4 + 1/8 × 4 +3/8 × 4 = 3 in^2 → shear stress S_s = 2000/3 = 667 psi

2. Section Modulus

$$\frac{I}{c_{top}} = \frac{bh^2}{6} = \frac{4 \times (1/8)^2}{6} = 0.00104$$

$$\frac{I}{c_{gusset}} = 2 \frac{(1/8) \times 4^2}{6} = 0.6667$$

$$\frac{I}{c_{base}} = \frac{4\times(3/8)^2}{6} = 0.09375$$

hence $\sum\frac{I}{c} = 0.7708$ in^3 → bending stress

$$S_b = \frac{F\times e}{I/c} = \frac{2000\times 2.25}{0.7708} = 5838 \text{ psi}$$

Combined maximum tension

$$S_t = \frac{S_b}{2} + \sqrt{\left(\frac{S_b}{2}\right)^2 + \left(\frac{S_s}{2}\right)^2} = 5857 \text{ psi}$$

Combined maximum shear

$$S = \sqrt{\left(\frac{S_b}{2}\right)^2 + \left(\frac{S_s}{2}\right)^2} = 2938 \text{ psi}$$

Note: Shear strength is 6 times tensile strength (p.264).

Size of Anchor Bolts

$$D_{bolt} = \sqrt{\frac{4A_b}{\pi}} = 0.16"$$

where $A_b = \frac{1}{NS_a}\left(\frac{4M_b}{D} - W\right) = \frac{1}{2\times 20{,}000}\left(\frac{4\times 4000\times 12/2}{20} - 4000\right) = 0.02$ in^2

The lugs should be located at least 2 feet from the end of the vacuum jacket to preserve the space for interconnection.

3.2.5 Pressure Relief Device

The cryostat is protected by pressure relief devices against excessive pressure build up in the vacuum space. The pressure in the cryostat will rise when cryogen leakage occurs. As the cryogen warms up in the cryostat, its volume expands rapidly. Since the vacuum jacket is not a coded pressure vessel, the maximum allowable internal pressure of the cryostat must be below 15 psi. The STL is an active (dynamic) system compared to passive devices such as cryogenic containers or gas cylinders. The recommended methods for relief device sizing from ASME, CGA, and API are not applicable to this situation. The nature of the venting process is rather complex even numerical simulations have to be based on assumptions. To size the pressure relief device, one needs to determine the ultimate flow requirement which is determined by the leakage rate and the cryogen evaporation rate once it is injected into the cryostat. First, check the venting condition and see if sonic flow is reached. Assuming isentropic flow, the relationship between the stagnation pressure P_o in the cryostat and the sonic pressure at the throat P_{sonic} can be used for the estimation (Liepman and Roshko, 1957)

$$\frac{P_{sonic}}{P_o} = \left[\frac{2}{k+1}\right]^{\frac{k}{k-1}}$$

At standard condition ($P = P_{atm}$, $T = 60$ °F = 288.56 K), the specific heat ratio k =1.6666. Substitute this value into the equation, we get $P_{sonic} = 0.4872P_O$ = 14.468 psia which is slightly below the atmospheric pressure. The uncertainly remains as to whether the flow is sonic at the throat. However, we know that if the downstream reservoir pressure P_{atm} is lower than or equal to the sonic pressure, then sonic flow is guaranteed at the throat. The codes allows a 10% margin above the maximum allowable working pressure (MAWP) during venting. This would given us a sonic pressure of P_{sonic} = 15.92 psia > P_{atm} which suffices the requirement for sonic flow at the throat. Therefore, the sizing of relief device can be based on sonic flow conditions on the warm (cryostat) side.

4. Interconnection

At final assembly, the construction units (straight module, elbow piece, and make-up piece) are to be field-joined. The cryogenic circuits are to be joined by stainless steel bellows through butt-welding. The thermal shield and MLI blankets do not require bridging. They enclose the joined section of circuit tubes between the longitudinal support from one module and the radial support from the other in the same way as that between two internal supports. Finally, the vacuum jackets of the joining modules need to be connected. Depending on the finalization of the external suspension system design, the vacuum jacket interconnection may be accomplished by use of a section of split shells (clam shells). The structure and installation methods of the interconnect region determine the required clearance between the shaft transfer line and the utility shaft wall. This clearance should be no more than 6 inches. An orbital welder will be used whenever possible. Longitudinal cutter can be used for the removal of the interconnect section of the vacuum jacket for maintenance and repair.

5. External Suspension System

The external suspension system holds the STL in designated locations. It anchors the STL to the utility shaft wall in the vertical section and to the concrete floor or ceiling in the horizontal sections.

5.1 Straight Module Supports

The straight module requires two external supports with one at each end. Each support assembly should provide the flexibility for three-dimensional adjustment. The strength requirements and calculations on the vacuum jacket side are given in 3.2.4. The strength requirements for the external supports are based on the loads. Each support should be able to bear the total weight of the straight module with a safety factor of two.

5.2 Elbow Piece Supports

Due to the use of bellows for the interconnection of the cryogenic circuit tubes, the hydrostatic loads from the circuit tubes are transmitted to the vacuum jacket of the elbow piece. The design of the external suspension system must be able to handle the resultant force corresponding to the operating mode which produces the most severe loading.[2] Depending on the final design or selection of the bellows for the internal circuit tubes, the thrust forces from the bellows calculated at design pressure should be included in the total load on the elbow piece supports. The external suspension system should also relieve stress from the vacuum jacket at the penetration to the neighboring equipment.

5.3 Thermal Expansion Consideration

The temperature environment for the shaft transfer line is between the surface building controlled temperature range (0°~50° C), and the controlled tunnel temperature range (80° ±5° F). The stress in the vacuum jacket due to temperature variation and the difference in thermal expansion between the vacuum jacket material (carbon steel) the concrete wall is well below allowable level (less than 1,500 psi for a temperature difference of 50° C). Therefore, from the thermal expansion/contraction point of view, the shaft transfer line vacuum jacket does not require expansion joints. However, the thermal stress imposes an additional loading on the external suspension system if the external supports along the utility shaft wall

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[2]Depending on the structure of the bellows, this operating mode could be either the normal operating or the CCWP mode.

are designed as rigid supports. Appropriate spring factor needs to be incorporated in the external suspension system design to avoid the use of bellows for the shaft transfer line vacuum jacket.

5.4 Location and Strength Requirement on Vacuum Jacket Attachment

The surface area for the external support attachment to the module vacuum jacket for external support is sized in such a way that the total loading for a module can be supported at one location. Sufficient clearance (2 feet minimum) should be reserved at both ends of a module for the installation of the interconnection.

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Appendix A. List of computer programs for transfer line design and analysis

- LOAD computes the static and dynamic load for each cryogenic circuit.
- SPAN determines the spacing between internal support based on a predetermined natural frequency.
- CENTER calculates the center of gravity for the plates of the internal suspension system. Weight distribution can be optimized to minimize the strength requirement.
- CENT calculates the center of gravity and hydrostatic load distribution on the internal suspension system for the elbow piece.
- LEAK estimates the heat leak through the MLI system. Heat transfer modes include radiation, solid conduction and residual gas conduction.
- MLI includes LEAK and calculates the temperature distribution in the shield.
- DPCV computes the pressure drop through a valve or the Cv value, valid when DP is less than 1/2 of the absolute upstream pressure.
- HS calculates the stress and buckling criteria for the vacuum barrier plates and shells.
- HB calculates the heat leak into the 4, 20, and 80 K circuits through a single vacuum barrier.
- TLFRIC (TLDP) calculates the pressure drops through the cryogenic circuit tubes
- TLPOINT determines the testing condition for heat leak into the transfer line circuits which offers the largest temperature drop across the testing section with minimum flow rate.
- SSCOND Heat leak through stainless steel cylinder by conduction.
- SSINT Heat leak into 4 and 20 K circuits through rods.

Appendix B. Design of Shaft Transfer Line Suspension System Testing Stand

A test stand is designed for the verification of the finite element analysis results. Hydraulic jacks (RCH-121 by Enerpac Industrial Hydraulic Tools) are used to simulate the actual loads from the cryogenic circuit tubes. The arrangement is shown in Figure B.1. Details on the testing procedure, strain gauge setup, and experimental data are presented in Stifle and Zhang (1993).

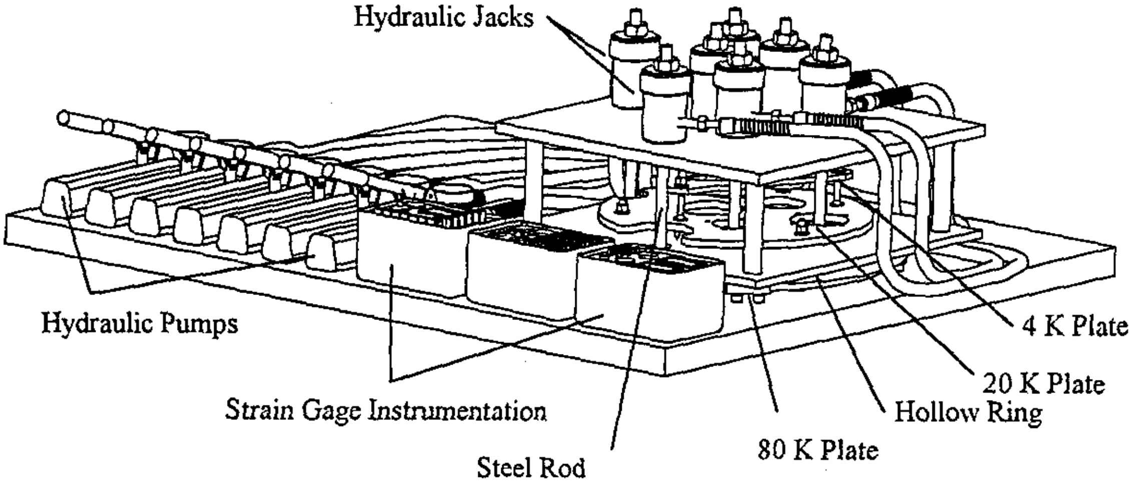

Figure B.1 Experimental apparatus for verification of stress in support system of transfer lines.

Appendix C. Alternative Design of the Internal Supports.

An alternative design of the internal support system will replace tubing with piping for the cryogenic circuits. Stainless steel 3" and 4" pipes are to be used for liquid/one-phase and vapor lines respectively. All pipes will be schedule 10. Based on a decision that eliminates the used of vacuum barriers in the cryostat anywhere except at the interfaces of the transfer line with neighboring equipment, the cryogenic circuit lines can be rearranged to yield a pattern that is easier to work with. Such pattern is shown in Figure C.1. It provides the accessibility of customized orbital welder heads to all circuit pipes for the field interconnect welding.

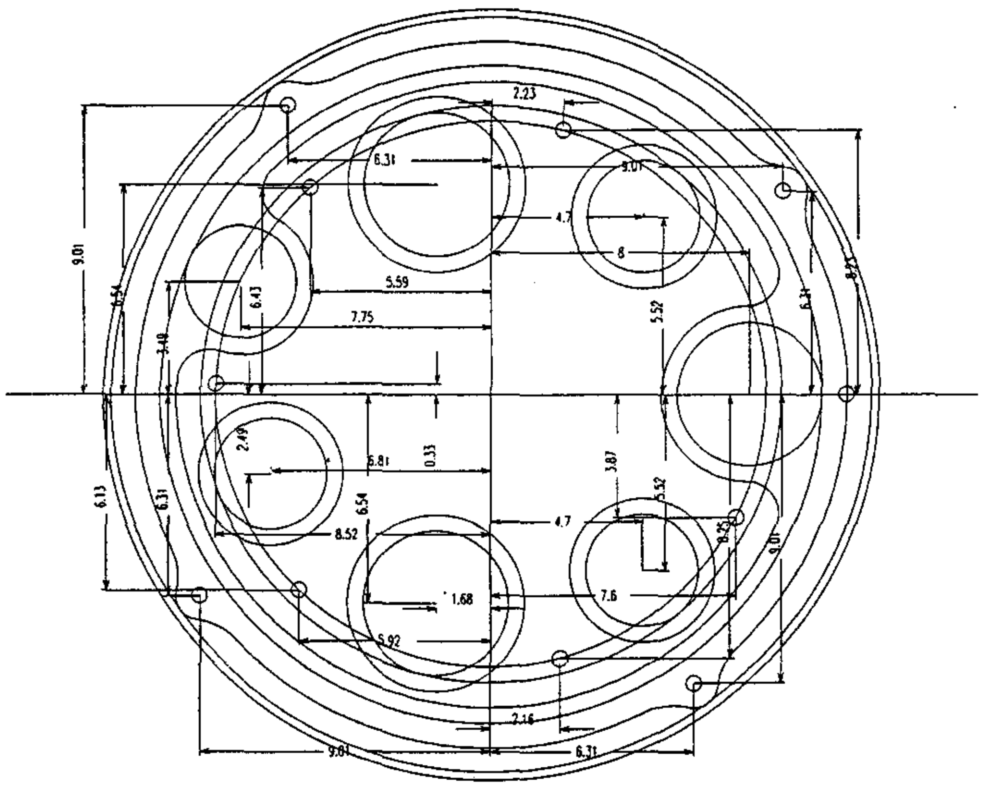

Figure C.1 Circuit pipe pattern of alternative design (pattern.dgn).

The increased inner diameters of the circuit pipes reduce the frictional pressure drops through the transfer lines. The disadvantage of such design is the weight increase due to the change in size and wall thickness of the piping. Consider the effective areas for the hydraulic loads, this design inevitably has much higher strength requirement on the elbow supports.

1. Introduction 1
  1.1 System Configuration 1
  1.2 System Requirements 3
  1.3 General Description 3
    1.3.1 Design Requirements 6
    1.3.2 Heat Leak Budgets 8
    1.3.3 Safety Devices 8
    1.3.4 Maintenance 9
    1.3.5 Interface 9
    1.3.6 Pressure Drops 9
    1.3.7 Assembly, Transport, and Handling 10
2. Internal Suspension System 11
  2.1 Straight Module Internal Suspension System 11
    2.1.1 Longitudinal Spacing between Supports 11
    2.1.2 Plate Thickness 12
    2.1.3 Heat Transfer Analysis 13
    2.1.4 Balance of Radial Support 13
    2.1.5 Installation of MLI Blankets 14
    2.1.6 Standoff Rods 14
  2.2 Elbow Piece Internal Suspension System 14
  2.3 Heat Leaks through Internal Suspension System 14
    2.3.1 Sizing for Copper Straps on Supports 15
3. CRYOSTAT 15
  3.1 Thermal Shield and MLI System 15
    3.1.1 Thermal Shield 15
    3.1.2 MLI Blanket 17
  3.2 Vacuum System 17
    3.2.1 Cryocondensation 18
    3.2.2 Cryosorption 18
    3.2.3 Vacuum Barrier 20
    3.2.4 Vacuum Jacket 21
    3.2.5 Pressure Relief Device 23
4. Interconnection 24
5. External Suspension System 24
  5.1 Straight Module Supports 24
  5.2 Elbow Piece Supports 24
  5.3 Thermal Expansion Consideration 24
  5.4 Location and Strength Requirement on Vacuum Jacket Attachment 25
References 25
Appendix A. List of computer programs for transfer line design and analysis 27
Appendix B. Design of Shaft Transfer Line Suspension System Testing Stand 28
Appendix C. Alternative Design of the Internal Supports. 29

STATEMENT OF WORK (SOW)

FOR THE

TRANSFER LINE SYSTEMS

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Transfer line System Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.1 Start of Work Meeting 4
3.1.2.2 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 6
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.4.3 Interface Control Documents (ICD) 7
3.2 Fabrication and Installation 7
3.2.1 Schedule 7
3.2.2 Shop/Field Witness Points 8
3.2.3 Material Control 8
3.2.4 Processes and Methods 8
3.2.5 Testing 8
3.2.6 Spares 9
3.2.7 Reserved 9
3.2.8 Installation 9
3.2.9 Maintenance Manual 9
3.3 Reserved 10
3.4 Reserved 10
3.5 Program Management 10
3.5.1 Contract Work Breakdown Structure (CWBS) 10
3.5.2 Lower Tier Subcontract Management 10
3.5.3 Program Schedules 11
3.5.4 Configuration Management (CM) and Control 11
3.5.5 System Safety 11

3.5.5.1 Safety Analysis 11
3.5.5.2 Material Safety Data Sheets (MSDS) 11
3.5.5.3 On-Site Activities 12
3.6 Quality Assurance 12
3.7 SSCL Numbering System 12
3.8 Units of Measure 12
3.9 Reserved 13
3.10 Management Reviews and Technical Meetings 13
3.10.1 Technical Interchange Meetings (TIM) 13
3.10.2 Technical Reviews 13
3.11 Technical Reports 13
3.12 Cost Reports 14
4.0 Reserved 14
5.0 Customer Furnished Property/Services 14
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 15

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Transfer Line Systems (TLS) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, and install one prototype Transfer Line System (TLS) at N15 of the Superconducting Super Collider Laboratory (SSCL).

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one TLS located at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. Technical and functional descriptions of the TLS are contained in AHW-XXXXX.XXX, Development Specification for the Transfer Line Systems.

Procurement of this prototype TLS is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objectives of this procurement are to deliver a production design with accompanying data and program management services, fabricate a prototype TLS, and install the prototype at site N-15 to support collider cooldown testing.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the TLS design requirements baseline in the form of a product fabrication specification and drawing package.

b. Present the design trade-offs, product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Fabricate the prototype TLS.

d. Installation and acceptance testing at the N-15 site of the SSC.

e. Maintenance and support of the prototype TLS during cool down testing at SSC.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Transfer Line System

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan (to be submitted with proposal)

c. Subcontractor Program Management Plan (to be submitted with proposal)

d. Subcontractor Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Development Specification for the Transfer Line System.

3.1 TRANSFER LINE SYSTEM DESIGN

The subcontractor shall design the TLS in accordance with the requirements of the Development Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Sections 3, 4 and 5.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the TLS. The equipment design shall be fully documented in accordance with the Development Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Development Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted not later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.1 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the TLS not later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Development Specification

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Interfaces

f. Design standardization and maintenance

g. Program Management Plan

h. Quality Assurance Plan

i. Configuration Management Plan

j. Program risk assessment

k. Problems and concerns

l. Test Planning

m. SSC Test Support

n. Installation planning

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.1.2.2 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the TLS not later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the TLS design has been completed. As a minimum, the following items shall be addressed:

a. Design

b. Interfaces

c. Drawings, Level 2

d. Specifications

e. Configuration Management

f. Acceptance Test Planning

g. Test Support Planning

h. System safety

i. Fabrication planning

j. Quality Assurance planning

k. Installation planning

l. Failure modes analysis (FMA)

m. Logistics

    1. Transportation, packaging, and handling

    2. Standardization

    3. Special tools and equipment requirements

    4. Spares requirements

n. Program and near term schedules.

o. Program risk assessments

p. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings, Level 2)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11- Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the TLS and replacement modules shall be consistent with the Development Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on TLS performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post-replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 – Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL-STD-490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Development Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11-Product Specification (C2b))

(CDRL No. 15-Process Specifications)

(CDRL No. 21 - Material Specifications)

3.1.4.2 **Drawings**

The subcontractor shall convert design requirements into practical design layouts (Level 1) and then convert design layouts into detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 -As Built Drawings)

3.1.4.3 **Interface Control Documents (ICD)**

The subcontractor shall support URA in producing the appropriate interface control document(s).

(CDRL No. 32– Interface Control Documents)

3.2 FABRICATION AND INSTALLATION

The subcontractor shall fabricate and install all components of the prototype TLS in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work.

3.2.1 **Schedule**

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 **Shop/Field Witness Points**

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop/Field functional tests.

b. Final shop/field pressure and temperature tests and vacuum leak checking.

3.2.3 **Material Control**

The subcontractor shall implement material control procedures in accordance with the TLS quality assurance program and TLS specifications. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 – Parts Qualification Plan)

3.2.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the TLS specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 – Process Specifications)

3.2.5 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the TLS components including all field assembly tasks. Tests required by the TLS specifications and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria,

b. Identification of equipment and supplies required,

c. Detailed test procedure,

d. Form(s) for reporting the test results.

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.4, above, or Section 3.2.10, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 – Fabrication Test Plan)

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test. (Note that this does not include acceptance tests). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.2.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.2.7 Reserved

3.2.8 Installation

The prototype TLS shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the TLS specifications and in this Statement of Work. This SOW considers installation tasks to include fabrication tasks accomplished in the field.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and leak checks.

3.2.9 Maintenance Manual

Prior to installation of the prototype TLS, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure. The manual shall include a list of all spares and equipment required for maintenance.

(CDRL No. 41– Maintenance Manual)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, and installation tasks defined by this SOW in accordance with the TLS Program Management Plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the TLS shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the TL and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA in accordance with Section F of the subcontract. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Reviews shall be held at the subcontractor's facility on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

TBD

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

TRANSFER LINE SYSTEMS
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2 3.10.1,.2	As Req'd	No
2	Meeting Minutes3.1.2.1,.2,	3.10.1,.2	As Req'd	Yes
5	Drawings, Level 23.1.2.2		30D CDR	Yes
7	Reliability Analysis	3.1.2.2 3.1.3.1	CDR	Yes
8	Failure Modes Analysis	3.1.2.2 3.1.3.2	CDR	Yes
10	Maintainability Program Plan	3.1.2.2	CDR	Yes
11	Product Specifications	3.1.2.2 3.1.4.1	30D CDR	Yes
12	As Built Drawings3.1.4.2		As Req'd	Yes
14	Parts Qualification Plan	3.2.3	60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.4	CDR 60D	Yes
17	Fabrication Test Plan	3.2.5	As Req'd	Yes
18	Witnessed Fabrication Test Results	3.2.5	FT 5D	No
19	Fabrication Test Report	3.2.5	As Req'd	No
20	Spare Parts List	3.2.6	60D Install	No
21	Material Specifications	3.1.4.1	CDR 60D	Yes
23	Acceptance Test Plan	3.1.2.2	CDR	Yes

27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.1.4.3	As Req'd	Yes
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
41	Maintenance Manual	3.2.9	120D Install	Yes

Delivery Examples- *CA 30D = 30 days after Contract Award, 30D CDR = 30 days before CDR*

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 5 - Drawings, Level 2

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,

b. probability of occurrence of each failure mode,

c. times during operation the failure mode can occur,

d. classification of the failure mode (critical, major, minor),

e. end item reliability when the failure occurs,

f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

CDRL 11 - Product Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 12 - As Built Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 14 - Parts Qualification Plan

The plan shall contain, but is not limited to ,the following

a. the inspections and tests necessary to qualify the part,

b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,

c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,

d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,

e. and the data to be recorded.

CDRL 15 - Process Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 17 - Fabrication Test Plan

Reference SOW paragraph 3.2.5

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 21 - Material Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program using a block diagram portrayal of the functions that must be met to satisfy the total acceptance program,

2. Milestones. Identifies the start and expected completion dates of each test to be performed,

3. Participation. Identifies the contractor and URA participation roles and responsibilities,

4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,

2. Number for each piece of equipment or item test will be performed,

3. Name and brief description of test to be performed,

4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;

2. All support equipment by description, nomenclature and serial number;

3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.
Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,

b. Time allocated for each topic of instruction,

c. Scheduled order of presentation,

d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

STATEMENT OF WORK (SOW)

FOR THE

TRANSFER LINE SYSTEMS
FABRICATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Production Readiness Review (PRR) 3
3.3 Fabrication 4
3.3.1 Schedule 4
3.3.2 Shop Witness Points 4
3.3.3 Material Control 5
3.3.4 Processes and Methods 5
3.3.5 Testing 5
3.3.6 Spares 6
3.3 Reserved 6
3.4 Reserved 6
3.5 Program Management 6
3.5.1 Contract Work Breakdown Structure (CWBS) 6
3.5.2 Lower Tier Subcontract Management 6
3.5.3 Program Schedules 7
3.5.4 Configuration Management (CM) and Control 7
3.5.5 System Safety 7
3.6 Quality Assurance 8
3.7 SSCL Numbering System 8
3.8 Units of Measure 8
3.9 Reserved 9
3.10 Management Reviews and Technical Meetings 9
3.10.1 Technical Interchange Meetings (TIM) 9
3.10.2 Resserved 9
3.11 Technical Reports 9
3.12 Cost Reports 9
4.0 Reserved 10
5.0 Customer Furnished Property/Services 10
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 11

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Transfer Line Systems (TLS) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to fabricate eleven (11) Transfer Line Systems (TLS) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the TLS are contained in the Product and Material Specifications for the Transfer Line Systems, document numbers, XXXXXXXXXX and XXXXXXXXXX, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one TLS located at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype TLS at N-15 of the SSC. The fabrication of eleven (11) production TLS, two (2) for the HEB and nine (9) for the SSC, is included in this option.

Procurement of these systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to deliver production TLS, with accompanying data and spare parts, in accrodance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Maintenance of the design baseline established under the basic contract.

b. Conduct of a Production Readiness Review (PRR).

b. Fabrication of eleven (11) production TL systems.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Transfer Line System

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

f. XXXXXXXXXX, Product Specification for the TL Systems.

g. XXXXXXXXXX, Material Specification for the TL Systems.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

d. Subcontractor Configuration Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Transfer Line System.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting of the TLS no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Configuration Management

f. Quality Assurance

g. Producibility

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 PRODUCTION READINESS REVIEW (PRR)

The subcontractor shall conduct a PRR no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that any TL system design problems encountered during development have been resolved, and that adequate documentation of technical readiness and anticipated production costs are available for production phase release. As a minimum, the following items shall be addressed:

a. Product design:

   1. Producibility,

   2. Review of design changes during first article build and install,

   3. Design validation for performance, reliability, and maintainability.

b. Plant capacity, skilled personnel, and training resources.

c. Production Engineering and Planning:

   1. Compatability of production schedule with delivery requirements,

2. Integration of manufacturing methods and processes with facilities, equipment, tooling, and layout.

d. Materials and purchased parts:

1. Completeness of bill of materials,

2. Identification of long lead items,

3. Adequacy of inventory control system.

4. Spare part requirements.

e. Quality Assurance.

f. Safety Program.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.3 FABRICATION

The subcontractor shall fabricate all components of eleven (11) production TLS in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of the production units will be in accordance with Section F of the subcontract.

3.3.1 Schedule

The subcontractor shall maintain a fabrication schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.3.2 Shop Witness Points

The following witness points shall be included in the subcontractor's fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.3.3 Material Control

The subcontractor shall implement material control procedures in accordance with the TLS quality assurance program, TLS system specifications, and the Parts Qualification Plan approved under the basic contract.

3.3.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special fabrication processes required to satisfy the provisions of the TLS specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.3.5 Testing

The subcontractor shall conduct a fabrication test program during fabrication and assembly of the TLS components. Tests required by the TLS specifications and the subcontractor's quality assurance program shall be included. The fabrication test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.3.2 and 3.3.4, above, the results shall be reported to URA within five (5) days of completion of the test.

(**CDRL No. 18** – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.3.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(**CDRL No. 20** – Spare Parts List)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the fabrication tasks defined by this SOW in accordance with the TLS program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the TLS shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of fabrication and installation processes. The subcontractor shall identify potential risk factors associated with fabrication, installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the TL system specificationd.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the TL and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Resserved

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

TRANSFER LINE SYSTEMS
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.10.1	As Req'd	No
2	Meeting Minutes	3.1. 3.10.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.2.5	FT 5D	No
19	Fabrication Test Report	3.2.5	As Req'd	No
20	Spare Parts List	3.2.6	PRR	No
27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	Updates	Yes
29	Material Safety Data Sheets	3.5.5.2	Updates	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No

__Delivery Examples__- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

STATEMENT OF WORK (SOW)

FOR THE

TRANSFER LINE SYSTEM
INSTALLATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Installation 3
3.2.1 Schedule 3
3.2.2 Witness Points 4
3.2.3 Processes and Methods 4
3.2.4 Testing 4
3.3 Program Management 5
3.3.1 Reserved 5
3.3.2 Reserved 5
3.3.3 Program Schedules 5
3.3.4 Reserved 5
3.3.5 System Safety 5
3.3.5.1 Safety Analysis 5
3.3.5.2 Material Safety Data Sheets (MSDS) 5
3.3.5.3 On-Site Activities 6
3.4 Quality Assurance 6
3.5 SSCL Numbering System 7
3.6 Units of Measure 7
3.7 Reserved 7
3.8 Management Reviews and Technical Meetings 7
3.8.1 Technical Interchange Meetings (TIM) 7
3.8.2 Resserved 7
3.9 Technical Reports 7
3.10 Cost Reports 8
4.0 Reserved 8
5.0 Customer Furnished Property/Services 8
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 9

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring the services required to install Transfer Line Systems (TLS) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to install eleven (11) Transfer Line Systems (TLS) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the TLS are contained in the Product and Material Specifications for the Transfer Line System, document numbers, XXXXXXXXXX and XXXXXXXXXX, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one TLS located at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype TLS at N-15 of the SSC. The installation of eleven (11) production TLS, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these services is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to perform the installations of production TLS in accordance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Conduct of a Start of Work Meeting

b. Installation of eleven (11) production TLS.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. AHW-XXXXX.XXX Development Specification for the Transfer Line System

b. Accelerator Systems Division Safety and Health Program Manual

c. SSCL Practice D10-000003, Hazard Analysis Instructions

d. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

e. XXXXXXXXXX, Product Specification for the Transfer Line System.

f. XXXXXXXXXX, Material Specification for the Transfer Line System.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Transfer Line System.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting for the installation of the TLS no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications and drawings

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Quality Assurance

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 INSTALLATION

The subcontractor shall install all components of eleven (11) production TLS in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of installation services will be in accordance with Section F of the subcontract.

3.2.1 Schedule

The subcontractor shall maintain an installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Witness Points

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Functional tests.

b. Final pressure and temperature tests and vacuum leak checking.

3.2.3 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special installation processes required to satisfy the provisions of the TLS specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.2.4 Testing

The subcontractor shall conduct a test program during installation and assembly of the TLS components. Tests required by the TLS specifications and the subcontractor's quality assurance program shall be included. The installation test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.2.2 and 3.2.3, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 – Witnessed Installation Test Results)

The results of all installation tests, including witnessed tests, shall be compiled by the subcontractor in an Installation Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. (Note that this does not include acceptance tests). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Installation Test Report)

3.3 PROGRAM MANAGEMENT

The subcontractor shall manage the installation tasks defined by this SOW in accordance with the TLS program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the TLS shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.3.1 Reserved

3.3.2 Reserved

3.3.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.3.4 Reserved

3.3.5 System Safety

3.3.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of installation processes. The subcontractor shall identify potential risk factors associated with installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the TLS specifications.

(CDRL No. 28– Safety Analysis)

3.3.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. *Control measures:* Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.3.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. *Training shall be coordinated with the SSCL System Safety Project Office.*

3.4 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.5 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL *for those documents delivered to the SSCL.* The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.6 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the TLS and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.7 RESERVED

3.8 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.8.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or

informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.8.2 Resserved

3.9 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.10 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

TRANSFER LINE SYSTEM
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.8.1	As Req'd	No
2	Meeting Minutes 3.1	As Req'd 3.8.1	No	
18	Witnessed Fabrication Test (FT) Results	3.2.4	FT 5D	No
19	Fabrication Test Report	3.2.4	As Req'd	No
27	Program Schedules	3.2.1 3.3.3	Monthly	No
28	Safety Analysis	3.3.5.1	Updates	Yes
29	Material Safety Data Sheets	3.3.5.2	Updates	Yes
30	Monthly Report	3.9	Monthly	No
31	Cost Reports	3.10	Monthly	No
36	Contractor Organization	3.3	CA 30D	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro
submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.4

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.4

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.3.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.
Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.3.5.2

<u>CDRL 30 - Monthly Report</u>

Reference SOW paragraph 3.9

<u>CDRL 31 - Cost Reports</u>

Reference SOW paragraph 3.10

<u>CDRL 36 - Contractor Organization</u>

Reference SOW paragraph 3.3

TECHNICAL SPECIFICATION

FOR THE

COLD COMPRESSOR SYSTEM

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

APPROVED:

W. FIETZ, HEAD DATE CRYOGENICS DEPARTMENT	T. KOZMAN, HEAD DATE ACCELERATOR SYSTEMS DIVISION
J. REES DATE SSCL PROJECT MANAGER	R. SCHWITTERS DATE SSC LABORATORY DIRECTOR

April 6, 1994

PREPARED BY:

J. LOBB DATE
CRYO PLANNING & DEVELOPMENT

REVIEWED:

D. EVANS, LEADER DATE
CRYO PLANNING & DEVELOPMENT

R. LUTHER, LEADER DATE
CRYO MECHANICAL ENGINEERING

D. HAWKINS, HEAD DATE
ASD SAFETY

J. WENTZ, HEAD DATE
ASD QUALITY ASSURANCE

Table of Contents
Cold Compressor Specification

1.0 Introduction and Scope
2.0 Applicable Documents
  2.1 Drawings Furnished by URA
  2.2 Standards
3.0 Requirements
  3.1 Performance
    3.1.1 Operating Modes
    3.1.2 Mode Stability
    3.1.3 Non-Mode
      3.1.2.1 Operating Condition Range
      3.1.2.2 Start / Restart
  3.2 Design
    3.2.1 General Mechanical Requirements
      3.2.1.1 Environmental Conditions
      3.2.1.2 Equipment Layout
      3.2.1.3 Materials
      3.2.1.4 Design Pressure
      3.2.1.5 Welding
      3.2.1.6 Joints and Seals
      3.2.1.7 Penetrations
      3.2.1.8 Safety Devices
      3.2.1.9 Cleaning and Surface Treatment
      3.2.1.10 Services
    3.2.2 General Electrical Requirements (check with Schuster)
      3.2.2.1 Enclosures
      3.2.2.2 Terminal Blocks
      3.2.2.3 Wiring, Cables, Connectors
      3.2.2.4 Grounding
    3.2.3 Compressor
      3.2.3.1 Type
      3.2.3.2 Speed and Power Margins
      3.2.3.3 Motor
      3.2.3.4 Motor Cooling
      3.2.3.5 Motor Purge Valve
      3.2.3.6 Hydrodynamic Gas Bearing
      3.2.3.7 Magnetic Levitation Bearing
    3.2.4 Rotating Assembly Dynamics and Design
      3.2.4.1 Definitions
      3.2.4.2 Critical Speeds
      3.2.4.3 Balance
      3.2.4.4 Thrust Bearings
      3.2.4.5 Journal Bearings
      3.2.4.6 Impeller Clearance
    3.2.5 Vacuum Enclosure
      3.2.5.1 Fabrication
      3.2.5.2 Bayonets
      3.2.5.3 Pressure Relief
      3.2.5.4 Vacuum Leakrate
      3.2.5.5 Limiting Weights and Dimensions

3.2.6 Local Control Unit
3.2.6.1 Control Interfaces with Refrigerator
3.2.6.2 Sensors and Transmitters
3.2.6.3 Instrumentation
3.2.6.4 Units
3.2.6.5 Alarms and Trips
3.2.6.6 Magnetic Levitation LCC
3.2.6.7 CCM Control
3.3 Reliability and Availability
3.3.1 Reliability
3.3.2 Mean Down Time
3.3.3 Availability
3.3.4 Maintainability
3.3.5 Design and Operation
3.3.6 Periodic Maintenance
3.4 Documentation
3.4.1 Submittals
3.4.2 Numbering
3.4.3. Design Basis Document
3.4.3.1 Compressor
3.4.3.2 Module
3.4.3.3 Local Control Center
3.4.4 Design Calculations
3.4.5 Component Design Data Sheets
3.4.6 Component Test Data Sheets
3.4.7 Drawings (this will need several subsections)
3.4.8 Specifications for Second-Tier Procurement
3.4.9 Interface Control Documents
3.4.10 Data Bases
3.4.11 Item-Specific Documentation
3.4.12 Spare Parts List
3.4.13 Maintenance Schedule
3.4.14 Environment, Safety, and Health
3.4.15 Manuals
4.0 Quality Assurance Provisions
4.1 Contractor Quality Assurance Plan
4.2 Access by URA
4.3 Responsibility for Inspection
4.4 FMECA
4.5 FRACS
4.6 Fabrication Testing in Contractor's Shop
4.7 Verification and Acceptance Testing at SSCL
4.8 Requirements Cross Reference
4.9 Quality Conformance Matrix

5.0 Packing and Delivery

6.0 Notes
- 6.1 Definitions
  - 6.1.1
  - 6.1.2 Drawings
    - 6.1.2.1 Layout
    - 6.1.2.2 Installation
    - 6.1.2.3 Installation Assembly
    - 6.1.2.4 Inseparable Assembly
    - 6.1.2.5 Separable Assembly
    - 6.1.2.6 As Built
- 6.2 RFI Responses
  - 6.2.1 Mechanical Design Concept
  - 6.2.2 Process Control Design Concept
  - 6.2.3 Services
  - 6.2.4 Ancillary Equipment
  - 6.2.5 Process Gas Filtration

SSC Laboratory
Cold Compressor System RFI

1.0 Introduction and Scope

The Cold Compressor maintains helium vapor pressure over magnet recooler baths at 0.75 bar (10.78 psia) and discharges to a surface refrigeration plant from 1.35 to 1.45 bar (19.57 to 21.02 psia). The pumped volume is approximately 100 m^3 (3531 ft^3).

The compressor interfaces with recooler baths and surface refrigerator via the Cold Compressor Box. Cold Compressor and Cold Compressor Box are located in an Adit area adjacent to the Tunnel.

The Cold Compressor will have its own vacuum enclosure and either socket directly into the Cold Compressor Box on bayonets as shown in Fig. 2.2-4 or be free standing and be connected via bayoneted "U" tubes. The choice of configuration is presently the contractor's option. Options will be reviewed after responses to this RFI.

The Cold Compressor Box has provision for an additional Compressor . The arrangement of process control valves allows this second machine to be used as a standby, or in future for parallel or series compression.

The basic cold compressor machine is referred to in the text as the Cold Compressor, and the assembly of Cold Compressor and Vacuum Enclosure as the Cold Compressor Module (CCM).

The CCM and associate controls are referred to in the text as the Cold Compressor System (CCS).

This Request for Information specification previews URA requirements for Cold Compressor Modules. Comments are solicited from contractors to aid in preparation of the Request for Proposal (RFP).

2.0 Applicable Documents

2.1 Drawings Supplied by URA

2.2-1 SSCL Main Accelerator Ring Plan View
2.2-2 *Sector Refrigerator System Block Diagram*
2.2-3 Cold Compressor Box schematic
2.2-4 Cold Compressor Vacuum enclosure Layout
2.2-5 Flow/Pipe/Component Symbols

2.2 Standards

The Contractor proposal shall list all applicable standards to be used in the design, construction, test, packaging and shipping. The following documents of the exact issue shown form a part of this document to the extent specified herein. If a conflict arises between the *documents referenced below and the contents of this specification, the latter shall prevail.*

2.2.1 Industry and Society Documents

a) American National Standards Institute (ANSI)
   1) ANSI/ASQC Q91-1987 , Quality Systems-Model for Quality Assurance in Design/Development, Production, Installation and Servicing.
b) American Society of Mechanical Engineers (ASME)
   1) Petrochemical Plant and Petroleum Refinery Piping B31.3.
   2) Building Services Piping B31.9.
c) National Electrical Code (NEC)
   1) *240, Overcurrent Protection*
   2) 250, Grounding
d) National Electrical Manufacturers Association (NEMA)
   1) Stds. Publication No. PR 4: Plugs, Receptacles and Cable Connectors of the Pin and Sleeve Type for Industrial Use.
   2) Stds. Publication No. 250: Enclosures for Electrical Equipment (1000 Volts Maximum)
e) International Standards Organization (ISO)
   1) ISO1000, (units)
d) *Compressed Gas Association (CGA)*
   1) CGA 341, Standard for Insulated Cargo Tank Specifications for
Cryogenic Vessels—3.6 General Requirements, Outer Shell.

2.2.2 SSCL Documents

1) P40-000119.A, Leak checking.
2) P40-000120.A, Processing of Stainless Steel Weldments for
HighVacuum Use.
3) AQA-1010097.0, Contracted Supplemental Welding and Brazing.

2.2.3 Government / Military Documents

1) *MIL-STD-1629, Failure Mode, Effects and Criticality Analysis (FMECA).*
2) MIL-STD-2155 (AS), Failure Reporting, Analysis, and Corrective Action System (FRACAS).
3) MIL-STD-130, Identification Marking.
4) DOD-STD-1000B, Drawings, Engineering, and Assembly Lists.
5) Ocupational Health and Safety Act, 29 CFR
   Part 1910, OSHA Standards
   Specific items to be listed by contractor during design stage.

3 Requirements

3.1 Performance

3.1.1 Operating Modes

The CCM is required to follow various anticipated plant operating modes which reflect both magnet system demand and refrigerator reliability. These are described as Design, Nominal, and Standby. Efficiencies given are the minimum required Isentropic efficiencies.

Table 3.1.1
Mode Performances

	P in (+/- 1%)	T in	P out (min)	Eff. % (min)	Flow
	bar	K	bar		g/s
Design	0.75	4.3	1.45	65	330
Nominal	0.75	4.3	1.4	60	264
Standby	0.75	4.3	1.35	55	138

3.1.2 Mode Stability

The compressor shall maintain an inlet pressure +/- 1% under stable conditions in any of its three modes. During transitions between modes the inlet pressure may vary by up to ± 5%. **NB: 1% controls at +/- 0.01K, 10% controls at +/- 0.1K, what level of control is absolutely necessary?**

The compressor must be able to withstand an inlet pressure excursion of dP/dt = 10%/sec to a maximum pressure of TBD during a quench of a full magnet string (1/4 sector) as shown in Fig. 2.2-1.

3.1.3 Non-Mode

3.1.3.1 Operating Condition Range

The compressor shall be capable of safe start, operation to design mode speed or motor shaft power, and shut-down under the conditions listed below. Operation time at design mode shall be unlimited.

(a) inlet pressures 0.6 thru 1.9 bar,
(b) outlet pressures 1.02 thru 1.9 bar,
(c) inlet temperatures 4 thru 300K.

3.1.3.2 Start/Restart

a. The compressor shall be tolerant to cool down thermal excursions of dT/dt = 100K/sec.
b. The compressor shall be capable of restart from Trip condition without repressurizing the supply (there is a nominal supply volume of $100m^3$ of 3.9K vapor).

3.2 Design

3.2.1 General Mechanical Requirements

3.2.1.1 Environmental Conditions

Tunnel:

a) Relative Humidity 80%
b) Temperature 80°F (27°C).
c) Structural Vibration:

It is predicted that structural vibrations in the machinery areas will be minimal. All local machinery will be rotating (vacuum pumps, circulating pumps), less than 10 kW power input and effectively vibration isolated from the structure.

Surface

Above ground all installations are to be designed for an ambient temperature range of -15°C (5°F) to 55°C (131°F), with the exception of equipment in the control room which shall be rated for temperatures within the range 10°C (50°F) to 32°C (90°F) and from 20% to 80% relative humidity.

3.2.1.2 Equipment Layout

3.2.1.3 Materials

a Proven mechanical items shall be used where possible. The number of original components and assemblies shall be minimized.

b All material and equipment must be new and suitable for the application.

c All machinery components shall be designed and constructed such that no damage occurs due to failure of a subsystem such as instrument air, cooling water, power, or computer systems.

d All devices such as instruments, valves, and filters shall allow for convenient inspection and maintenance.

e All the equipment shall be painted to URA specification.

f Assemblies and machined pieces operating at low temperature (less than 270 K) shall be constructed of materials known to be appropriate for cryogenic applications.

g The selection and combination of materials shall be such that no significant galvanic corrosion can occur.

h All instrument air manifolds shall be protected with an "air set" containing a water/oil trap and particulate filter.

i All instrument tubing shall be stainless steel.

j The use of epoxies or other similar materials shall require prior approval of URA.

k All system piping shall conform to ASME B31.3.

3.2.1.4 Design Pressure

3.2.1.4.1 Helium Systems

Helium containment design pressure shall be 10 bar (145 psia). Pipework inside the vacuum enclosure shall be designed for 10 bar (145 psia) pressure difference. Pipework attached to the compressor shall conform to ASME B31.

3.2.1.4.2 Water Systems

All water circuits shall be rated for at least 10 bar (145 psia).

3.2.1.5 Welding

Welding shall comply with the requirements of:

ASME B31.3.
SSCL Document P40-000120.A
SSCL Document AQA-1010097.0

3.2.1.6 Joints, Seals, and Valves

a All joints which form a barrier to helium gas leakage into the vacuum space shall be welded. There shall be no demountable joint under these conditions without the written approval of URA.

b All seals, joints, and welds must be double acting, holding pressure as well as vacuum.

c Any installed joints or welds for temperature service less than 270 K shall be designed for 10,000 temperature cycles from 400 K to 4 K without loss of vacuum integrity.

d Demountable joints forming a seal between helium and atmosphere shall be O ring sealed. There shall be no compressed gaskets, compression fittings or thread sealants. The required surface finish for O-ring seals with elastomer gaskets must be better than 1.5 microns rms, and for all metal seals better than 0.3 mm rms.

e The design and construction of demountable seals shall be such that the joint can be broken and reestablished at least 20 times without damaging the sealing surfaces.

f Small couplings (up to 10 mm pipe size) for service at more than 270 K in helium pipework and at connections to valves and instrumentation shall be Parker UltraSeal, Cajon VCO or equivalent zero clearance fittings commercially available in the USA. Compression fittings are not acceptable for helium service.

g All valves shall be bellows sealed.

3.2.1.7 Penetrations

All vacuum vessel penetrations shall be designed such that the temperature of any point on the surface of the vessel is within 5°C of ambient temperature. The penetrations shall also allow for thermal movement over the entire operating temperature range.

3.2.1.8 Safety Devices

System shall have safety devices to meet applicable codes and regulations and to protect personnel and equipment during malfunctions and fault conditions. Pressure-relief valve settings shall conform to the requirements given elsewhere in this specification and to the applicable standards. **Unless otherwise stated, relief valve settings shall be a minimum of 2 bar or 10% above normal operating pressures, whichever is greater.** Piping and system design shall meet or exceed the above relief valve pressure rating.

a All volumes throughout the system which have a potential for exceeding the design pressure shall be equipped with relief valves.

b Relief valve ports of vessels and chambers with superinsulation shall be screened to prevent inlet blockages.

c All relief valves shall be easily demountable for inspection and resetting.

d Use of burst discs shall be minimal and shall require URA approval.

e All cryogenic pressure relief devices shall be located so that there is unobstructed access to them with a hot-air blower.

3.2.1.9 Cleaning and Surface Treatment

a Cleaning of internal surfaces of piping (including field-installed piping) vessels, valves, and devices shall meet requirements for normal refrigeration/cryogenic equipment not exposed to liquid air or oxygen, per ASTM A 380-88. The contractor shall submit detailed cleaning procedures before construction starts.

b All flux residue from brazed or soldered connections, all weld spackle and slag, and all sand and other particulates shall be removed. Systems shall be drained and purged of all solvents and be thoroughly dried.

c Visual inspection under bright and black light shall indicate no moisture, rust, foreign matter, film, or accumulation of oil, grease, or paint.

d Cleaned internal surfaces shall have sufficient protection to maintain established cleanliness.

e All carbon-steel surfaces exposed to atmosphere shall be sand-blasted. The contractor shall then apply one (1) shop coat of rust-inhibitive primer and two (2) 50 microns (0.002") shop coats of enamel (dry film thickness). Color scheme will be given by URA after design approval.

3.2.1.10 Services

a The system shall require no external services apart from electrical power and 100 psig (6.9 bar) instrument air.

b Instrument air consumption shall not exceed 2 scfm (56 l/min).

3.2.2 General Electrical Requirements

3.2.2.1. Enclosures

a All enclosures shall be NEMA 12 standard.

b. Enclosures shall be located for access from a normal work surface and have an electrical hazard decal located on the door

c Enclosures shall house only electrical and/or fiber optic devices.

3.2.2.2 Terminal Blocks

a The terminal blocks of the electric cabinets shall have a reserve of at least 10% spare terminal points.

b Terminal points shall be numbered on the terminal block, and each terminal block shall be numbered.

c All terminal blocks shall be rated for the highest voltage present on that terminal block.

3.2.2.3 Wiring, Cables, Connectors

3.2.2.3.1 Wiring

a All wiring shall be installed in a good and workmanlike manner, suitable for the environment in which it is installed, and shall conform to NEC Article 300.

b All wiring shall meet UL VW-1 Vertical Flame Test.

c For all applications above 250K, the contractor shall use stranded copper wire with suitable insulation for the application. For all applications below 250K, the contractor shall use stranded copper wire with PTFE insulation unless noted elsewhere in this specification. Field instrumentation wiring shall be shielded cables of twisted pairs, twisted triples, or twisted quads. Exceptions must be approved by URA.

d Both ends of all cables and conductors shall be labeled according to a logical labeling scheme (see Sections 3.6.7.4 and 3.6.7.5). Wires not soldered to plugs or sockets shall be terminated at a terminal point. Spare wires or cables shall not be left loose.

e Plugs, sockets, and terminals shall be wired according to the electrical elementary through the entire system.

f. Plugs and sockets shall be rugged industrial type with strain relief clamp and quick coupling which can be bayonet or other locking system. Soldered—or, preferably, crimped—gold plated pins shall be used. In case identical connectors are selected for different functions, the socket and plug insert shall be keyed at different angles.

g. The socket end of a connector shall always be the powered end.

h. Connectors at more than 3^{0}C (5^{0}F) below ambient shall be hermetically sealed to prevent condensation wetting of the connection.

i. Wire ties are not permitted inside conduit, cable tray, or wiring duct.

j. Analog signal cable shall be physically separated from other types of control and power cable.

k. No more than two wires per terminal point shall be permitted .

l. The contractor shall ground all equipment, per NEC Article 250, to the system ground that is supplied by URA.

m. All shielded cables shall be grounded on one end only. All shielded cables that do not enter the interface rack shall have their shields connected to a common point (insulated from equipment ground) and that point shall be connected to the URA supplied instrument ground.

3.2.2.3.2 Color codes

a. Three-phase wiring shall be color coded as follows:

Phase 1	BROWN
Phase 2	ORANGE
Phase 3	YELLOW
Neutral	GRAY
Ground	GREEN

On the larger size wires that are not available with color-coded insulation, the contractor shall use 1" wide colored tape to color code the wire at the terminal end.

b. Control and single phase power shall be color coded as follows:

ac line voltage	BLACK
ac control voltage	RED
ac neutral	WHITE
dc control	BLUE
Ground	GREEN
External source	YELLOW

On the larger size wires that are not available with colored coded insulation, the contractor shall use 1" wide colored tape to color code the wire at the terminal end.

c. Multiconductor cable color code shall be the cable manufacturer's standard color code.

3.2.2.3.3 Connectors

a. All crimp connectors shall be installed with a ratchet type crimping tool.

b. All crimp connectors shall be of the insulated type for wires AWG #10 and smaller, except where noted.

c. Devices with pigtail connections shall be connected utilizing a bolted splice and insulated with a minimum of three layers of electrical tape.

d. *Crimp type wire splices are not permitted.*

e. Plugs and receptacles shall comply with standards set out in NEMA Stds. Publication No. PR 4.

3.2.2.3.4 Cable Identificatioation

a. Cable marking shall be of the wrap type marker with a clear heat shrinkable sleeve to protect the marker.

b. Cable numbering shall be in a format of XXX-XX-XXX; as in the following table:

First group	Site location (N15, N25, etc.)
Second group	Equipment type (CC = cold compressor, etc)
First digit of third group	Cable type (P = power, C = control, A = analog)
Remaining digits of third group	Cable number (1, 4, 10, etc.)

For example, cable number *N25-CC-1A4* would be a cable at site location *N25,* equipment type *Cold Compressor # 1,* an *analog* signal, the *fourth* cable in a series of analog cables for Compressor # 1.

3.2.2.3.5 Wire identification

a. Wire markers shall be of the heat shrinkable sleeve type.

b. Wire numbers shall be a four-digit number. The first two digits shall indicate the sheet number of the elementary, and the second two digits shall indicate the wire on that sheet.

3.2.2.3.6 Panel indicator Light Bulbs

All bulbs in panel-installed control buttons, alarms, and indicator lights shall be the longest possible lifetime (e.g., neon or LED type). Incandescent bulbs which require frequent replacement shall be avoided.

3.2.2.4 Grounding

All electrical equipment shall be grounded in accordance with NEC 250 and have overcurrent protection in accordance with NEC 240.

3.2.3 Compressor

This performance specification shall be met by a system incorporating a single Cold Compressor and associated Control Unit(s).

3.2.3.1 Type

The compressor shall be a rotating centrifugal machine with one stage of compression. It shall employ hydrodynamic gas lubricated bearings, or magnetic primary bearings, or a combination of these.

3.2.3.2 Speed and Power Margins

The compressor shall have a speed capability of 115% of Design Mode speed, and a shaft power capacity 120% of Design mode power.

3.2.3.3 Drive Motor

The drive motor shall be AC synchronous. The motor stator shall be axially located between the compressor journal bearings.

3.2.3.4 Motor Cooling

3.2.3.4.1 General

Any cooling system provided by the contractor shall be self contained, and shall require no external services other than electrical power and instrument air.

3.2.3.4.2 Water Cooling

a The water cooling system shall be built to ASME B31.9.

b Solder joints and compression fittings shall not be used.

c Water circuits shall be fabricated in stainless steel pipe or tube.

d Any pipework flexibility necessary to isolate vibration or to facilitate servicing or repair shall provided by stainless steel hose sections.

e The water circulation pump shall be magnetically driven.

f All water connections broken to carry out Cold Compressor servicing or replacement shall be self-sealing.

3.2.3.4.3 Cryogen Cooling

a Contractors are invited to consider helium lead cooling flow from the Compressor process end, to reduce motor cold end temperatures and thermal conduction through shaft and body heat breaks. Lead cooling flow would discharge from the top of the motor enclosure to a low pressure return. Helium lead cooling flow shall not exceed 1.0 gm/sec.

b Provision of cryogen cooling for the compressor motor (other than that suggested in 3.2.3.4.3 a) is discouraged but liquid nitrogen will be considered if specification performances can not otherwise be met. Liquid nitrogen motor cooling is exceptional to the requirements of this specification, and the implications of cost, reliability, and performance will be considered before presentation of the Request for Proposal (RFP).

3.2.3.5 Motor Purge Valve

A valved atmospheric vent shall be included in the motor casing warm end to purge the motor of air during installation.

3.2.3.6 Atmospheric Leakrate

a. The integral leakrate between Cold Compressor and atmosphere shall be < $1x10^{-5}$ mbar l/s measured according to SSCL Document P40-000119.A00.

b. The leakrate from individual demountable seals shall be < $1x10^{-7}$ mbar l/s measured according to SSCL Document P40-000119.A00

3.2.3.7 Hydrodynamic Gas Bearing

The compressor shall meet the performance requirements specified herein after no fewer than 100 stop/start cycles from static to Design mode speed with a maintained outlet pressure of 1.02 bar maximum and without any interim maintenance or repair.

3.2.3.8 Magnetic Bearing

a. The compressor shall meet performances specified in this document after at least 5 failures of its entire active magnetic (primary) bearing system at Design mode speed without any maintenance or repair.

b. Loss of levitation which initiates motor shut-down shall be sensed at the compressor.

c. The lubricants in secondary (backup) bearings shall have a vapor pressure less than 1 x 10^{-3} mbar.

d. Rolling element secondary bearings shall not rotate by windage.

3.2.4 Rotating Assembly Dynamics and Design

3.2.4.1 Critical Speeds

a. The maximum continuous rotor speed shall be no greater than 80% of the first bending critical speed.

b. Standby speed shall be more than 25% above journal bearing resonance frequencies (first and second critical speeds).

c. Journal bearing resonance frequencies (first and second critical speeds) and rotating assembly first bending critical speeds shall be determined analytically and shall be confirmed by test.

3.2.4.2 Balance

a. Diametral concentricity of all shaft diameters shall be within 0.0002 inch (5 microns) of the axis of the shaft journal bearing surface.

b. The rotating assembly shall be multiplane dynamically balanced during assembly. The shaft shall be balanced alone, and each element of the assembly balanced separately on the shaft. Threaded components necessary to secure an element shall be considered part of that element.

c. The maximum residual unbalance after balancing the shaft, and every additional element shall be less than:

4W/N oz inch (or 6350W/N gm mm)

where W = balanced assembly static weight lb (Kg), and N = Maximum continuous speed rpm.

d. The shaft shall be symmetrical about its axis. Any keyway shall be balanced by a keyay on the opposite side and in the same axial plane.
e. The method of attaching elements to the shaft shall adequately maintain concentricity and balance under all specified operating conditions, including overspeed to trip speed.
f. The method of attaching elements to the shaft shall ensure repeatable quality of balance after dismantling and reassembly.
g. Each removable element of the rotating assembly shall be provided with an area as close as practical to its mass center for material removal during balance. Each element shall be permanently marked to aid correct angular realignment on the shaft.

3.2.4.3 Thrust Bearings

a. Thrust bearings shall have adequate capacity to control the axial clearance between impeller and shroud so that process gas recirculation is limited to a level consistent with process performance requirements.
b. Thrust bearings shall have capacity to prevent rotating assembly touch down on any static surface under all specified operating conditions, including surge.
c. Calculation of thrust forces shall include, but not be limited to, the effects of rotating assembly mass and impeller pressure difference under all specified operating conditions.
d. Thrust design shall include consideration of thrust surface thermal distortion by gas film shear, and dynamic stress distortion of the thrust disc.
e. The thrust disc shall be integral with the shaft.
f. Thrust disc surfaces shall be flat and perpendicular to the shaft journal surfaces axis within 0.0004 inch (10 microns).

3.2.4.4 Journal Bearings

a. Journal bearings shall have capacity to prevent rotating assembly touch down on any static surface under all specified operating conditions, including overspeed to trip.

3.2.4.5 Impeller Clearance

a. There shall be static (bearings deactivated) axial clearance between impeller and shroud at all temperatures within the specified operating range.
b. *Hydrodynamic*
Journal bearing clearances shall be used to determine an impeller to shroud radial clearance that avoids contact in full conical whirl (second mode bearing).
c. *Magnetic*
Secondary journal bearing clearances extant after 3 failures of the primary bearing at Design speed shall be used to determine an impeller to shroud radial clearance that avoids contact in a full conical whirl (second mode bearing).

3.2.5 Vacuum Enclosure

3.2.5.1 Fabrication

a. Fabrication shall conform to the general requirements in section 3.2.1
b. The enclosure and process pipework shall be fabricated from 304 stainless steel and designed in accordance with CGA 341.
c. The maximum process gas pressure drop at design mode condition between bayonets and compressor shall be:

Inlet 1 mbar
Outlet 1 mbar

d. The layout and support of cold piping and components shall allow for thermal contraction without generation of excessive stresses.
e. The enclosure shall have a thermocouple vacuum gauge tube with a bellows sealed isolation valve. These shall be readily accessible for troubleshooting and maintenance. The gauge tube shall have physical protection.
f. The enclosure shall have a 50mm KF flange vacuum connection.

3.2.5.2 Bayonets

a. The enclosure shall have either male or female process inlet and outlet bayonets depending upon CCM configuration (see Section3.2.1.12). Male bayonets shall extend vertically downwards, and female receptors vertically upwards.
b Full Bayonet specifications and designs will be provided by URA with the RFQ.

3.2.5.2.1 Direct Mounting Male Bayonets

a. Current designs require a minimum 12 inches (305 mm) and maximum 20 inches (508 mm) between male bayonet centers at the cold compressor box. The heat break length will be 30 inches (762 mm) minimum.
b. Mutual flexibility (angularity and center to center) between male bayonets is necessary to guarantee alignment with the Cold Compressor Box bayonet sockets.
Mutual angular displacement: $>2^0$
Center to center movement: >0.040 inches (1.0 mm)

3.2.5.2.2 Direct Mounting Mechanical interface

For direct mounting to the Cold Compressor Box the connection must be robust enough that it can carry the assembly weight and avoid damage resulting from rotating mass stored energy in seizure, or damaging vibrations caused by failure of primary bearings.

The following is suggested:
a. The vacuum enclosure has a rigid extension concentric with the inlet bayonet and that the extension is flanged. The flange will be bolted to a 4" bayonet isolating ball valve mounted on the cold compressor box.
b. Mutual flexibility of male bayonets will be provided by bellows sections in the outlet bayonet.

3.2.5.2.3 U Tubes

"U" tubes (if applicable) will be procured separately to the CCM procurement.

3.2.5.3 Pressure Relief

a. The enclosure shall be equipped with an atmospheric pressure relief plate capable of handling the total cold compressor flow capacity with a maximum pressure difference of 100 mbar.
b. Robust screens shall be provided on the vacuum side of the port to limit the hazard of blockage by superinsulation. The screen projected area shall be no less than 4 x port area.
c. The relief plate shall be readily accessible, and easily removed for inspection and service after release of vacuum.
d. The use of burst discs shall require URA approval.

3.2.5.4 Vacuum Leakrate

a. The leakrate to the vacuum enclosure measured according to SSCL Document P40-000119.A00 shall be as follows:
Atmosphere to vacuum $<1\times10^{-6}$ mbar l/s
Helium to vacuum $<1\times10^{-9}$ mbar l/s
b. The vacuum enclosure shall be designed for a sustained maximum pressure of $<1\times10^{-3}$ mbar over a period of twelve (12) months for operating and non-operating conditions.

3.2.5.5 Limiting Weights and Dimensions

3.2.5.5.1 Direct Mounting Configuration

The overall height of the Module including bayonet length shall not exceed 5 feet (1524 mm). The total Module weight shall not exceed 300 lbs (136 Kg).

3.2.5.5.2 Free Standing Configurations

The footprint for a free standing design shall not exceed 6' x 4' x TBD high (1829 mm x 1219 mm x TBD mm high). The total Module weight shall not exceed 2000 lbs (908 Kg).

3.2.6 Local Control Center

3.2.6.1 Interfaces with Refrigerator Control

3.2.6.1.1 Physical Interface

a. The physical interface between the Sector Refrigerator Control (SRC) and the Local Control Center (LCC) will be at the URA interface rack located at Adit level and separated from the Cold Compressor Box by approximately 100 ft (30m).

The contractor shall provide all interconnections between the interface rack and LCC.

b. URA will assign all terminal points in the interface rack. The procedure for assigning the interface rack terminals will be as follows:

1. The contractor shall draft the electrical elementary showing the connections to the interface rack using a symbol such as a triangle. Sufficient space shall be allocated to the right of the symbol for the URA supplied terminal number.
2. The contractor shall then submit the drawings to URA for approval.
3. Upon receiving these drawings, URA will determine according to the architecture of the control system the exact location that each wire shall be connected to in the interface rack.
4. URA will return a copy of the marked-up electrical elementary to the contractor for the incorporation of the URA supplied interface terminal numbers.

3.2.6.1.2 Electrical Interface/Signal Conditioning

a. All analog signals to and from interface rack shall be linear.

e. The sensor output to the interface rack can be linear, nonlinear, continuous, or pulsed, but shall conform to Section 3.2.6.1.2.

b. Signals shall be conditioned as follows:

1. All analog signals from contractor equipment to URA control equipment shall be source 4-20 mA. The electrical specifications for the URA analog input modules are as follows:

o Type of input Analog
o Rated voltage 20–28 V dc
o Input current range 4-20 mA
o Input resistance 500 ohms

2. All analog signals from URA control equipment to contractor equipment will be source 4-20 mA. The electrical specifications for the URA analog output modules are as follows:

o Type of output Analog
o Rated voltage 20–28 V dc
o Output current range 0–20 mA
o Max. loop resistance 600 ohms

3. All digital signals from contractor equipment to URA control equipment shall be +24 V dc "true." The electrical specifications for the URA discrete input modules are as follows:

o Type of input: Discrete
o Rated voltage 24 V dc
o Operating voltage range 0–30 V dc
o Voltage range for "ON" 14.0–30 V dc
o Voltage range for "OFF" 0.00–5.0 V dc
o Input current for "ON" 2.0–15.0 mA
o Input current for "OFF" 0.5 mA

4. All digital signals from URA control equipment to contractor equipment shall be + 24 V dc logic "true" rated at 0.5 A. The electrical specifications for the URA discrete output modules are as follows:

o Type of output Discrete
o Rated voltage 6–24 V dc
o Operating voltage range 4.5–34 V dc
o Temporary overload 2.0 A for 1 ms
o Max. "ON" state voltage drop 1.8 V dc
o Max. "OFF" state leakage current 0.2 mA

Where special equipment signal levels do not conform to this listing, the contractorshall supply interface electronics to convert to the standard process signals shown. This interface electronics will be subject to URA approval. Any signal different from the standard signals defined here is subject to URA approval.

c. All device malfunctions shall produce a signal logic "false." Normal operation within accepted limits shall produce logic "true."

d. Signal conditioning units shall be installed in a contractor-supplied AMCO #8211 rack, which shall be married to the URA-supplied interface rack (see Section 3.2.5.1.1).

e. Signal conditioning units shall be located within those stations.

3.2.6.2 Sensors and Transmitters

a. The CCM shall be equipped with sensors as necessary to provide for its safety and protection, and manual and automatic remote-controlled operation.

b. All sensor outputs shall be connected to the LCC for remote monitoring and data acquisition at the SRC. The minimum sensor monitoring requirement is given in 3.2.6.5.

c. All sensors may be state of the art but must have proven reliability, accuracy, reproducibility, long time stability, and maintainability. Sensors shall have a past history of at least 20,000 hours of continuous operation in a similar application. Sensors that do not meet this requirement shall not be used without prior URA approval.

d. Sensor signal dependence on ambient temperature and cable length shall be minimized.

e. The sensor output to the interface rack can be linear, nonlinear, continuous, or pulsed, but shall conform to Section 3.2.6.1.2.

f. All sensors shall be labeled with a permanent tag, numbered as shown on the P&IDs.

g. All sensor installations shall allow for easy replacement of the sensor without opening helium circuits or vacuum spaces to atmosphere. Redundant sensors shall be installed at all points where replacement is difficult. All spare redundant critical control point sensors shall be connected to the URA interface rack.

h. Loop response time shall be less than .05 sec from sensor input to interface.

3.2.6.2.1 Pressure Sensors

a. Pressure and vacuum instrumentation such as pressure transducers and vacuum gage tubes shall have an isolating valve to facilitate replacement, servicing, or recalibration.

b. Helium pressure sensors shall be capable of withstanding 15 bar pressure without requiring recalibration.

c. Pressure sensor loop accuracy shall meet or exceed the following full-scale specifications:

Accuracy	± 0.5%
Sensitivity	0.1%
Repeatability	0.1%
Stability	± 0.1%/yr

3.2.6.2.2 Power Consumption Measurement

All three phases of the power supply shall be included in the active power consumption measurement, which shall be accurate to within ±1% of full scale.

3.2.6.2.3 Current

Currents up to 5 A shall be measured with an accuracy better than 0.5%. Currents above 5 A, which require transformers in the measurement chain, shall be determined with an accuracy of ±1.5%.

3.2.6.2.4 Voltage

Voltages up to 600 V shall be directly measured with an accuracy better than 0.5%. Voltages which require transformers in the measurement chain shall be determined to an accuracy of ± 1.5%.

3.2.6.3 Instrumentation

a. The minimum instrumentation requirement for the CCM is given in Table 3.2.5.3. The use of closed circuit cooling water is assumed. The contractor shall specify any other parameters which are necessary or usefully monitored for CCM control, protection, and availability.

b. Detail of Instrumentation requirement

1. The compressor shall be provided with a vibration detection system. The early warning or shutdown for excess vibration due to abnormalities and wear in the compressor assemblies shall be designed to prevent equipment damage.

2. Each phase of the motor winding shall be equipped with at least one temperature sensor.

3. Each thrust and journal bearing shall be provided with at least one imbedded temperature sensor.

4 Hours run, and starts counters shall be non-resettable.

Table 3.2.5.3
CCM Instrumentation

LCC display	SRC (remote)	Instrument
X	X	Compressor inlet pressure
X	X	Compressor outlet pressure
X	X	Compressor motor input power
X	X	Compressor motor winding temperature
X	X	Compressor bearing temperature
X	X	Compressor vibration monitor
X		Compressor start counter
X		Compressor hour meter
X	X	Compressor shaft speed
X	X	Cooling water flow
	X	Cooling water inlet temperature
	X	Cooling water outlet temperature
X		Cooling water temperature rise
X	X	Vacuum enclosure pressure

3.2.6.4 Units

The units given below are preferred for all instrumentation readouts supplied with the system, any deviations require URA approval. English equivalents mentioned in the text are for clarification only and should not be used in instrumentation readouts.

a. All pressures shall be given in bar absolute unless noted otherwise.

b. Vacuum readings shall be given in millibar (mbar) absolute.

c. Temperatures shall be given in either K or °C as noted. In general, it is preferred that temperatures be expressed as Kelvin for the range below ambient, and in degrees Celsius for the range above ambient. For the purposes of this RFI, the ambient temperature T_0 is assumed to be 305 K.

d. Flow rates shall be given in grams per second (g/s).

e. Time shall be given in seconds or hours as noted.

f. Standard S.I. units (see Standard ISO 1000) shall be used for all other quantities.

3.2.6.5 Alarms and Trips

a. The contractor shall furnish a list of alarms and alarm levels that may be usefully implemented in the SRC.

b. An emergency stop due to any CCM component or control failure shall be fail-safe. No externally implemented protection logic will be provided.

c. LCC shall contain all the hardwired safety alarms and shutdowns required for safe operation.

d. Trips shall have first out display and alarms, trips and first out status shall be relayed to the SRC.

e. As a minimum requirement the contractor shall provide the alarms and trips listed in Table 3.2.5.4. The use of closed circuit cooling water is assumed.

Table 3.2.5.4
Alarms and Trips

Alarm	Trip	Parameter
X	X	Compressor motor input power
X	X	Compressor motor winding temperature
X	X	Compressor bearing temperature
X	X	Compressor vibration monitor
X	X	Compressor shaft speed
X	X	Cooling water flow
X	X	Cooling water temperature rise
X		Vacuum enclosure over pressure

3.2.6.6 Magnetic Levitation LCC

a. The LCC shall be designed for ease of re-characterizing to a new bearing system in the event of a cold compressor exchange.

b. The LCC shall have battery back-up to maintain bearing levitation on power outage. Levitation shall be maintained for the time required for the rotating assembly to stop from design mode speed. Backup shall be sized for no fewer than 3 consecutive outages without battery recharge.

It is anticipated that there will be 12 power failures per calendar year and the duration of failure 15 cycles minimum.

3.2.6.7 CCM Control

a. After a trip shutdown has occurred, the LCC shall require a reset command to unlatch the safety shutdown function from the LCC (if the control is set to local) or from the SRC (if set to remote). The compressor shall not restart until the reset command has been received (all safeties unlatched). When the control is set to the remote mode, the SRC shall command the LCC to start/stop the compressor and reset the shutdown status function(s). Transfer to and from the SRC shall be bumpless.

b. The LCC shall enable either Manual or Automatic speed control. Automatic speed control will respond to inlet pressure. The contractor shall provide pressure transducers to monitor and control inlet pressure and to monitor outlet pressure. These transducers shall be installed by URA. The inlet pressure control loop performance shall be consistent with requirements in 3.1.2.3

c. The LCC low voltage section shall contain the compressor's local start/stop controls. A key-operated local/ remote switch to transfer the control of the compressor to the SRC shall also be located in the LCC low voltage section. Transfer of control between SRC and LLC shall be bumpless.

3.3 Reliability and Availability

The system shall be designed for high reliability meeting performances specified in this document without maintenance or repair for periods of at least 8000 operating hours.

3.3.1 Reliability

The mean time between failures (MTBF) of each CCM shall be at least 6,000 hours.

For purposes of this calculation, any reduction of the CCM performance below minimum mode requirement given in Section 3.1.1 shall be termed a failure and shall count in the assessment of MTBF.

3.3.2 Mean Down Time

The mean down time (MDT) for the CCM shall be no greater than six (6) hours. For the purposes of this calculation, MDT is measured from the point at which CCM performance falls below minimum mode requirement given in Section 3.1.1 and the point when that performance is restored.

3.3.3 Availability

CCM availability shall be calculated as:

$$\text{Availability} = \frac{\text{Scheduled Uptime - Unscheduled Downtime}}{\text{Scheduled Uptime}}$$

The minimum availability of each CCM shall be at least 0.99875.

3.3.4 Maintainability

The CCM shall be designed for ease of fault diagnosis and correction. Items liable to failure shall be readily accessible so that URA technician personnel can easily, safely, and reliably carry out any necessary inspection, maintenance or repair.

3.3.5 Operation

The contractor is encouraged to discuss operating strategies which will improve the availability of the CCM.

3.4 Documentation

3.4.1 Submittals

a. For each submittal, three (3) copies of all engineering documentation shall be submitted as follows: **(Specific guidelines shall be given in following sections.)**

o Two (2) paper copies

o One (1) electronic copy on 3.5" floppy diskette formatted for Macintosh or PC-DOS.

b. The numbering system for all engineering documents shall be in accordance with this technical specification, Appendix D.

3.4.1.1 URA Engineering Approvals

All contractor engineering documentation shall be sent to the SSCL for approval by URA and thirty (30) days shall be allowed for that approval.

3.4.1.2 Text Document Formats

a. Text documents are documents other than drawings and databases (e.g., specifications, operating and maintenance manuals) which are part of the engineering function.

b. Text documents shall be electronically created and maintained using either of the following software packages:

1. Microsoft Word for Macintosh, v5.0 unless a later version is authorized by URA.
2. Microsoft Word for Windows (IBM PC compatible), v2.0 unless a later version is authorized by URA.

c. Operating and maintenance manuals delivered with standard, off-the-shelf equipment procured by the contractor is not required to be delivered in electronic format unless readily available.

3.4.1.3 Drawing Formats

a. All drawings delivered to the SSCL shall be CAD drawings.

b. Manual and/or electronically scanned drawings are not acceptable.

c. All drawings shall be submitted as follows:
1. Paper: one (1) vellum and one (1) blue-line or equal
2. Electronic: either of the following formats:
   Intergraph/MicroStation (preferred) PC 4.0 or later
   AutoCAD v10 or later

d. If CAD files are translated from electronic format different from AutoCAD or MicroStation, the contractor shall examine the translated CAD file using either AutoCAD or MicroStation to assure accuracy and completeness of the translation. This shall be accomplished prior to sending the translated files to the SSCL.

e. Drawings reduced from their original size are not acceptable, unless specifically requested by URA.

f. The maximum size drawing submitted shall be E-size (44" x 34").

g. Drawings on architectural size paper shall not be allowed.

h. All revisions of a drawing shall be indicated on the drawing by clouding and shall specifically be noted in the revision block of that drawing.

i. General revisions to drawings shall not be allowed.

j. As-built drawings shall be submitted in full size and shall be printed on mylar.

k. Parts lists/bills of material shall be prepared integrally with any drawings where it is required and shall be shown on the first sheet of those drawings.

l. The contractor shall use either the S.I. or English system for design documentation and drawings. **The system selected by the contractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.4.2 Document Numbering

All CCM documents shall be numbered A H A - XXXXX, where XXXXX is a unique document number in the sequence 60000 to 60999.

The contractor shall subdivide the sequence 60000 to 60999 in some logical order to localize document significance.

3.4.3 Design Basis Document

The design basis document shall include the following information:

3.4.3.1 Compressor

3.4.3.1.1 General

a Weight (kg):
b Proportions (mm):
c Rotating assembly axis (vertical/horizontal):

3.4.3.1.2 Bearings

a Primary bearing type, manufacturer, and model No.:
   Journal:
   Thrust:
b Secondary bearing type, manufacturer, and model No.:
   Journal:
   Thrust:
c Primary journal bearing radial clearance
   Cold end nominal: Tolerance (mm): ±
   Warm end nominal: Tolerance (mm): ±
d Secondary journal bearing radial clearance
   Cold end nominal: Tolerance (mm): ±
   Warm end nominal: Tolerance (mm): ±
e Center line distance between:
   Primary journal bearings (mm):
   Secondary journal bearings (mm):
g Secondary bearing lubricant

Journal: vapor pressure (mbar):
Thrust: vapor pressure (mbar):

h Surface finishes to limit bearing touch-down abrasion
Journal:
Thrust:

3.4.3.1.2 Impeller

a Design:
b Fabrication detail:
c Maximum impeller overhang from
Primary journal (mm):
Secondary journal (mm):
d Radial clearance impeller eye diameter to shroud (mm):
e Impeller inlet diameter (mm):
f Impeller outlet diameter (mm):

3.4.3.1.3 Diffuser

a Design:
b Fabrication detail:

3.4.3.1.4 Balance

a Number of major elements balanced (excluding shaft):
b Maximum location clearance to shaft (diametral):
Static:
Element 1:
Identity: Clearance (mm):
Element 2:
Identity: Clearance (mm):
At design speed:
Element 1:
Identity: Clearance (mm):
Element 2:
Identity: Clearance (mm):

3.4.3.1.5 Materials and heat treatments:

a Shaft;
b Impeller:
c Other:

3.4.3.1.6 Temperatures in Design, Nominal, and Standby modes:

a Motor stator (C):
b Thrust bearing surface or winding (C):
c Journal bearing surface or winding
Cold end bearing (C):
Warm end bearing (C):

3.4.3.1.7 Motor

a Design, manufacturer, and model No.:
b Controller electrical input (phase, frequency, and voltage, current):
c Power Input power in Design, Nominal, and Standby modes(W):
d Power losses in, Design, Nominal, and Standby modes
Copper losses (resistance) (W):
Core losses (including hysteresis and eddy currents) (W):
Bearing friction losses (W):
Windage losses (W):
e Shaft power in Design, Nominal, and Standby modes (W):
f Efficiency in Design, Nominal, and Standby modes (%):

3.4.3.1.8 Motor cooling

a Circuit design:
b Services and demand:
c Cooling medium:
d Cooling medium Specific heat (j/gmC):
e Design , Nominal, and Standby modes:
Flow:
Inlet temperature (C):
Outlet temperature (C):
Heat removed (W):

3.4.3.1.9 Conduction/convection heat transfer to process:

a Thermal conduction:
via housing sections (W):
via shaft sections (W)
via baffles and insulators(W):
b Thermal convection from bearing/motor system
Natural (W):
Forced in Design, Nominal, and Standby modes (W):

3.4.3.1.10 Rotor Dynamics

a Critical speeds:
First critical (bearing) (Hz):
Second Critical (bearing) (Hz):
Third critical (bending) (Hz):
b Mode speeds:
Design (Hz):
Nominal (Hz):
Standby (Hz):
c Maximum continuous speed (Hz):
d Failure speed (Hz):
e Impeller peripheral velocity at design speed (m/s):
f Thrust disc peripheral velocity at design speed (m/s):
g Rotating assembly stored energy at design spee (j):

3.4.3.2 Compressor Module

3.4.3.2.1 General

a Weight (kg):
b Proportions (mm):

3.4.3.2.2

3.4.3.3 Local Control Center

3.4.3.3.1 General

a Weight (kg):
b Proportions (H mm x W mm x D mm):

3.4.3.3.2

3.4.4 Design Calculations

a. Process pipework stress calculations.

3.4.5 Component Design Data Sheets

Description and uses

A component design data sheet shows the complete engineering criteria necessary for the design or selection of a component.

Requirements

Component design data sheets shall be developed and provided to URA for all equipment for both process and mechanical design. These shall include the compressor, heat exchangers, pumps, and valves. The subcontractor may use its standard data sheets for these items.

3.4.6 Component Test Data Sheets

Description and use

A component test data sheet shows the types of tests performed on a given component and the results of those tests as used in the design verification and/or calibration of the component.

Requirements

Component test data sheets shall be developed, completed after component test, and provided to URA for all the applicable equipment. This applies to both process and mechanical testing of the components. All applicable test data sheets shall be provided for compressor, heat exchangers, pumps, and valves. The subcontractor may use its standard data sheets for these items.

3.4.7 Drawings

In particular the following drawings are required:

a. Layout drawing of cold compressor, vacuum enclosure and cold pipework showing the arrangement of pipework to control thermal stresses.

b. *Layout drawing of CCM units giving principal dimensions and weights.*

c. Detail design of cold compressor showing:

1. the disposition of primary and secondary bearings
2. motor cooling system
3. location and type of temperature sensors

3.4.8 Specifications for Second Tier Procurement

Specifications for all equipment (instrumentation, electrical, mechanical, etc.) or materials procured by the contractor for this contract shall be submitted to URA.

3.4.9 Interface Control Documents

The contractor documentation shall define all interfaces between the CCM and the Collider system. This shall include all instrumentation I/O, alarms, trips, etc. (see Section 3.2.5) routed to the interface rack, and connetction points for instrument air and electrical power.

The following shall be specified:

a. Electrical power voltage, phase, and current.

b. Instrument air flow and pressure.

3.4.10 Data Bases

3.4.11 Item Specific Documentation

3.4.12 Spare Parts List

The Contractor shall propose maintenance spare parts stocking for 24000 hrs operation consistent with the availability requirements in Section 3.3.3.

Spare parts that can be sourced within the USA and have a value less than $100 (such as "O" rings and fasteners) shall be specified.

If the number of start-ups is significant in determining the maintenance interval, the contractor shall assume 100 start-ups per 10,000 hrs of machine operation.

3.4.13 Maintenance Schedule

The contractor shall supply a maintenance schedule that meets the level of CCM availability specified in section 3.3.3.

CCM elements which are necessarily returned to the contractors shops for repair or maintenance shall be identified.

3.4.14 Environment, Safety, and Health

The DOE and URA are committed to the policy of ensuring that all activites associated with the construction and operation of the SSCL shall be in compliance with the applicable federal and other environment, safety, and health regulations.

The contractor shall provide a list of all hazardous materials, as listed by OSHA and/or EPA, used in construction, installation, testing, maintenance, and repair of the CCM on URA sites and shall provide a copy of the Material Safety Data Sheet (MSDS) for each hazardous material listed.

The contractor shall require of all subcontractors, employees, agents, and all other persons performing work at URA sites the same responsibility for the aforesaid safe use, storage, and disposal of such materials. The contractor shall require its subcontractors, materialmen, agents, employees, and other persons performing work to use a substitute for any specified hazardous material whenever so directed by URA. All hazardous material brought onto the construction site or other SSCL premises shall bear a label stating the identity of the material, any hazards associated with it, and the name of the party responsible for bringing such material onto the site.

Any waste in any form which results from the work must be properly disposed of by the subcontractor in a safe manner, protective of the environment and in accordance with all applicable laws. The contractor shall be considered the generator and owner of any hazardous substances, pollutants, or contaminants it may bring onto the work site or that may be generated as a result of its performance of the work.

4.0 Quality Assurance Provisions

4.1 Contractor Quality Assurance Plan

The contractor shall maintain a quality assurance plan that conforms with ANSI/ASQC Q91-1987 , Quality Systems-Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

4.2 Quality Audits

a. The contractor shall cooperate fully with URA audits of compliance with 4.0 These shall be conducted before award of contract and periodically thereafter.

b. Under section 4.6.4 of ANSI/ASQC Q91-1987, URA elects the option to carry out verification at any subcontractor's plant. This will not be used by the contractor as evidence of effective control of quality by the subcontractor.

c. The contractor shall give URA 5 days minimum notice of subcontractor acceptance inspections and tests.

d. Subcontractors and suppliers of parts or assemblies which have a direct impact on reliability shall be identified by the contractor. These shall include, but not be limited to, parts or assemblies of the following:

o Motor and motor control system.

o Bearings and bearing control system.

o Motor cooling system.

e. Supplier specifications for all equipment (instrumentation, electrical, mechanical, etc.) or materials procured by the contractor for this contract shall be made available to URA on request.

f. The subcontractor's quality system shall have control provisions for the conduct of audits, source inspection, and surveillance of external organizations and activities that affect the quality of deliverables. These quality verification activities shall be performed by qualified personnel who are independent of the organization(s) responsible for the performance of the work and attainment of the specified quality.

4.3 Responsibility for Inspection

According to the CCM Statement of Work

4.4 FMECA

Failure mode, effects and criticality analysis (FMECA) shall be performed initially at the conceptual subsystem level, and then subsequently to lower levels as the designs are developed and as determined necessary by the criticality of the modes identified at higher levels of analysis. The FMECA shall be performed and documented using MIL-STD-1629 as a guide throughout the design phase.

During the test phase the contractor shall implement a failure reporting, analysis, and corrective action system detailed in Section 4.5.

4.5 FRACAS

The contractor shall implement a failure reporting, analysis, and corrective action system (FRACAS) during development, site commissioning, and early operating phases using MIL STD 2155(AS) as a guide.

The contractor shall identify and discuss the procedures that will be used to control failure report initiation, failure analysis, and feedback of corrective actions into the design, manufacturing and test process. The plan submitted for review shall describe the flow of failed hardware and failure data through the contractor's organization.

The contractor shall identify failure review board (FRB) members and indicate the extent of their authority. The FRB shall identify trends, corrective action status, and assure adequate corrective actions are taken.

4.6 Testing in Contractor's Shop

URA reserves the right to designate selected manufacturing, inspection, and/or test operations as "witness" and/or "hold" points during the review cycle of the contractor's inspection plans. The contractor shall provide URA with five (5) working days' notice in advance of reaching such witness/hold points during the manufacturing and test cycle of each item.

Shop witness points shall include the following:

- o Compressor tests: leakage, pressure, and dynamic balance of rotating assembly.
- o Functional tests of mechanical equipment and functional tests of all instruments and sensors.
- o Final pressure, leak, temperature tests on each assembly prior to shipping.

4.7 Verification and Acceptance Testing at SSCL

On-site installation witness points and final acceptance shall include:

- o Pressure, vacuum, and leak tests.
- o Functional check of machinery operation (168 hr test of compressors), coolant circulators, etc.
- o Functional, calibration check of instruments.
- o Cooldown, warmup, and transient response, and for capacity and efficiency tests described in Section 3.9.
- o Fail safe checks, water, air supply, power supply and computer failure.
- o Inspection of wiring and functional test of electrical components

4.8 Requirements Cross Reference

4.9 Quality Conformance Matrix

SECTION PARAGRAPH	VERIFICATION METHOD				
	DEMO	ANAL	TEST	EXAM	N/A
3.0 Requirements					X
3.1 Performance					X
3.1.1 Operating modes			X		
3.1.2. Mode stability			X		
3.1.3 Non-mode			X		
3.1.3.1 Operating condition range			X		
3.1.3.2 Start/Restart			X		
3.2 Design					X
3.2.1 General Mechanical requirements					X
3.2.1.1 Environmental conditions					
3.2.1.2 Equipment layout					
3.2.1.3 Materials					
3.2.1.4 Design pressure					
3.2.1.4.1Helium systems					
3.2.1.4.2 Water Systems					
3.2.1.5 Welding					
3.2.1.6 Joints, seals and valves					
3.2.1.7 Penetrations					
3.2.1.8 Safety devices					
3.2.1.9 Cleaning and surface treatment					
3.2.1.10 Services					
3.2.2 General electrical requirements					
3.2.2.1 Enclosures					
3.2.2.2 Terminal blocks					
3.2.2.3 Wiring, cable, connectors					
3.2.2.3.1 Wiring					
3.2.2.3.2 Color codes					
3.2.2.3.3 Connectors					
3.2.2.3.4 Cable identification					
3.2.2.3.5 Wire identification					
3.2.2.4 Panel indicator light bulbs					
3.2.2.5 Grounding					
3.2.3 Compressor					
3.2.3.1 Type					
3.2.3.2 Speed and Power Margins					
3.2.3.3 Motor					
3.2.3.4 Cooling					
3.2.3.4.1 General					
3.2.3.4.2 Water Cooling					
3.2.3.4.3 Cryogen Cooling					
3.2.3.5 Motor purge valve					
3.2.3.6 Atmospheric leak rate					
3.2.3.7 Hydrodynamic gas bearing					
3.2.3 8 Magnetic bearing					

4.9 **Quality Conformance Matrix**

SECTION PARAGRAPH	VERIFICATION METHOD				
	DEMO	ANAL	TEST	EXAM	N/A
3.2.4 Rotating assembly dynamics and design					
3.2.4.1 Critical speeds					
3.2.4.2 Balance					
3.2.4.3 Thrust bearings					
3.2.4.4 Journal bearings					
3.2.4.5..Impeller clearance					
3.2.5 Vacuum enclosure					
3.2.5.1 Fabrication					
3.2.5.2 Bayonets					
3.2.5.2.1 Direct mounting male bayonets					
3.2.5.2.2 Direct mounting mechanical interface					
3.2.5.2.3 U tubes					
3.2.5.3 Pressure relief					
3.2.5.4 vacuum leakrate					
3.2.5.5 Limiting weights and dimensions					
3.2.5.5.1 Direct mounting configuration					
3.2.5.5.2 Free standing configurations					
3.2.6 Local control center					
3.2.6.1 Interfaces with refrigerator control					
3.2.6.1.2 Electrical interface/signal conditioning					
3.2.6.2 Sensors and transmitters					
3.2.6.2.1 Pressure sensors					
3.2.6.2.2 Power consumption measurement					
3.2.6.2.3 Current					
3.2.6.2.4 Voltage					
3.2.6.3 Instrumentation					
3.2.6.4 Units					
3.2.6.5 Alarms and trips					
3.2.6.6 Magnetic levitation LLC					
3.2.6.7 CCM control					
3.3 Reliability and availability					
3.3.1 Reliability					
3.3.2 Mean down time					
3.3.3 Availability					
3.3.4 Maintainability					
3.3.5 Operation					
3.4 Documentation					
3.4.1 Submittals					
3.4.1.1 URA engineering approvals					
3.4.1.2 Text document formats					
3.4.1.3 Drawing formats					

4.9 Quality Conformance Matrix

SECTION PARAGRAPH	VERIFICATION METHOD				
	DEMO	ANAL	TEST	EXAM	N/A
3.4.2 Document numbering					
3.4.3 Design basis document					
3.4.3.1 Compressor					
3.4.3.1.1 General					
3.4.3.1.2 Bearings					
3.4.3.1.3 Impeller					
3.4.3.1.4 Diffuser					
3.4.3.1.5 Balance					
3.4.3.1.6 Materials and heat treatment					
3.4.3.1.7 Temperatures					
3.4.3.1.8 Motor					
3.4.3.1.9 Motor cooling					
3.4.3.1.10 Conduction/convection					
3.4.3.1.11 Rotor dynamics					
3.4.3.2 Module					
3.4.3.3 Local control center					
3.4.4 Design calculations					
3.4.5 Component design data sheets					
3.4.6 Drawings					
3.4.7 Specifications for second tier procurement					
3.4.8 Interface control documents					
3.4.9 Data bases					
3.4.10 Item specific documentation					
3.4.11 Spare parts list					
3.4.12 Environment, safety, and health					
3.4.13 Manuals					
4.0 Quality assurance provisions					
4.1 Contractor quality assuance plan					
4.2 Quality audits					
4.3 Responsibility for inspection					
4.4 FMECA					
4.5 FRACS					
4.6 Testing in contractors shop					
4.7 Verification and acceptance testing at SSCL					
4.8 Requirements cross reference					
4.9 Quality conformance matrix					
4.10 Deviation requests					
4.11 Nonconformance reports					

5.0 Packing and Delivery

Proper protection for shipping loads and for prevention of environmental stress shall be provided during transportation, hauling, and storage.

a. All items heavier than 20 kg shall have lugs to permit lifting into place. Any special lifting gear such as spreader bars shall be furnished by the contractor. URA will retain all special lifting gear, if it is required, for maintenance.

b. In order to prevent corrosion, all cryogenic and vacuum assemblies shall be filled with dry gas at 1.5–2.0 bar or vacuum as appropriate during storage, transportation, and installation. The type of gas or vacuum used shall be clearly documented by the contractor on the crates and vessels and in the shipping papers.

c. Fragile items must be protected from shock during shipment.

d. Shipping labeling shall be per Mil Standard 130, Identification Marking.

e. *Operational warning signs and tags shall be per OSHA standards.*

6.0 Notes

6.1 Definitions

6.1.1 Rotating Assembly
The assembly of all rotating components.

6.1.2 Shaft
The one piece mandrel that locates all other elements of the rotating assembly.

6.1.3 Impeller
The rotating section through which the process gas total pressure is increased.

6.1.4 Thrust Bearing
Provides axial support of the rotating assembly.

6.1.5 Journal Bearings
Provides radial support of the rotating assembly.

6.1.6 Secondary bearing
Provides rotating assembly support in the event of primary bearings failure. (otherwise known as backup bearing).

6.1.7 Thrust Disc
A radial bearing surface on the rotating assembly.

6.1.8 First Critical Speed

6.1.9 Second Critical Speed

6.1.10 Third Critical Speed
Otherwise known as First Bending Critical Speed

6.1.11 Pressure (P)
Static pressure, measurement makes no allowance for velocity pressure.

a. All process points are measured as static pressures. Wall tap shall be 4 mm or smaller in diameter, with a sharp, burr-free edge, installed normal to flow boundaries in straight tube or pipe sections. Combined pressure/temperature taps are not acceptable.

6.1.2 Drawings

6.1.2.1 Layout

Description and use

A layout drawing shows the design concept with design information requiring special consideration by the engineer and draftsman—i.e., special clearances, adjustments, equipment provisions, materials, processes, finishes, critical tolerances, and other special features. It serves as an engineering worksheet from which engineering drawings are made. The drawing is not used for fabrication, procurement, or inspection.

Requirements

Layout drawings shall be produced at the system (skid arrangements), module (equipment on skids) and unit levels (individual pieces of equipment).

Identify the drawing as "DESIGN LAYOUT" above the title block in letters 0.25" high.

Specify all necessary design information—dimensions, tolerances, special clearances (e.g., maintenance, work space, safety) adjustments, materials, finishes, processes, etc.

All layout drawings shall show all known equipment whether provided by URA or by the contractor.

All equipment shall be shown to scale. Schematic representations shall not be allowed.

6.1.2.2 Installation

Description and use

An installation drawing shows configuration envelope and complete information necessary to install an item relative to its supporting structure or to associated items. An installation drawing may show a specific completed installation. Installation drawings for one-of-a-kind installation may be revised to record the as-installed or as-built condition.

Requirements

a. Installed item(s) shown in solid lines; other items (structures, etc.) in phantom.

b. Interface mounting and mating information, such as dimensions of location for attaching hardware.

c. Interface pipe and cable attachments required for the installation and co-functioning of the item to be installed with related items.

d. Information necessary for preparation of foundation plans, including mounting place details, drilling plans and shock mounting and buffer details.

e. Location, size and arrangement of ducts.

f. Weight of unit.

g. Location, type, and dimensions of cable entrances, terminal tubes and electrical connectors.

h. Reference notes to applicable lists and assembly drawings.

When not disclosed on other referenced documents, the following shall be included:

1. Overall and principal dimensions in sufficient detail to establish the limits of space in all directions required for installation, operation and servicing.

2. The amount of clearance required to permit the opening of doors or the removal of plug-in units.

3. Clearance for travel or rotation of any moving parts, including the centers of rotation, angles of elevation and depression.

The installation drawing shall include a parts list to establish the requirements for the installation hardware and the items being installed.

6.1.2.3 Installation Assembly

Description and use

An installation assembly drawing shows the installed and assembled position of an item relative to its supporting structure or to associated items.

Requirements

a. List of items to be installed
b. Locating dimensions and associated tolerances
c. Types and quantities of attachment
d. Process and special installation requirements
e. Adjustment data
e. Special test or inspection requirements
f. Detail definition of special installation parts

6.1.2.4 Inseparable Assembly

Description and use

An inseparable assembly drawing shows the assembled relationship of two or more parts, separately fabricated and permanently joined together by brazing, cementing, riveting, soldering, welding, etc., and not subject to disassembly. Their future use is considered as a single item if it be the end item or in subsequent assemblies.

Requirements

The drawing shall fully define the end product as assembled. Any dimensions that are not characteristic of the end product are informational and should be identified as "REF."

Part of an inseparable assembly may be defined on separate detail drawings or on the inseparable detail drawing.

6.1.2.5 Separable Assembly

Description and use

A separable assembly drawing shows the assembled relationship of two or more items where at least one of the items is capable of disassembly or servicing or replacement without causing destruction of any of the items for its designed use. The parts are normally identified as an assembly.

Requirements

a. Present sufficient views to show the relationship between each part composing the assembly.

b. Cite associated lists, installation drawings, wiring and schematic diagrams, etc., as applicable.

When an installation drawing is called out in the associated parts list, include a delta note as follows: "FOR INSTALLATION, REFER TO DRAWING XXXXXXX."

6.1.2.6 As-Built

Description and use

As-built drawings document for any item, deviations from design or fabrication drawing specifications, and items which are cut- or built-to-fit in the shop or field.

Requirements

Requirements for each individual type of drawing apply.

6.2

6.3 RFI Responses

The purpose of the CCM RFI is to provide Suppliers with draft requirements, and from responses to formulate a RFP which most appropriately meets the needs of SSCL.

Suppliers are encouraged to consider cold compressor machines in which the compressor shaft is magnetically levitated, if different from their established designs. Non-contacting magnetic levitation is currently the URA preferred bearing technology.

In addition to making general comments on the RFI, Suppliers are asked to respond to the specific issues below in order that URA can finalize designs for the prototype Cold Compressor Box and make provision for tunnel cold compressor services.

6.3.1 Mechanical Design Concept

Suppliers are requested to provide conceptual arrangements of cold compressor vacuum enclosure showing, in particular:

a) principal weights and dimensions,

b) internal pipework showing bellows arrangement,

c) compressor proportions, attitude and weight.

6.3.2 Process Control Design Concept

The Contractoris requested to consider and inform URA how to control process gas at trip and on compressor re-start to avoid repressurizing the recooler vapor return line (see ???) and recommend control that mitigates compressor surge.

6.3.3 Services

Details of anticipated utilities requirements are requested, in particular

a) Compressor motor cooling medium, heat extracted and flow.

b) Electrical power requirements.

6.3.4 Ancilliary Equipment

Suppliers are requested to estimate weights and dimensions of ancillary equipment (e.g. enclosures, cooling circuit, vacuum system) indicating clearances necessary for personnel to carry out maintenance and repair, and limitations on location with respect to environmental conditions and physical separation from the cold compressor.

6.3.5 Process Gas Filtration

Suppliers are requested to advise SSCL of the minimum necessary quality of compressor inlet process gas filtration. This is to be expressed as absolute efficiency rating (i.e. 99.99% removal of "X" micron particle size).

STATEMENT OF WORK (SOW)

COLD COMPRESSOR SYSTEMS
FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

18 FEBRUARY 1993

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 2
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Cold Compressor System Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.2 Preliminary Design Review (PDR) 4
3.1.2.3 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 7
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.5 Prototype Build and Test 8
3.2 Fabrication 8
3.2.1 Design Revision 8
3.2.2 Production Readiness Review (PRR) 8
3.2.3 Schedule 9
3.2.4 Shop Witness Points 10
3.2.5 Material Control 10
3.2.6 Processes and Methods 10
3.2.7 Testing 10
3.2.8 Spares 11
3.2.9 Long Lead Items 11
3.3.10 Installation 11
3.3 Logistics 11
3.3.1 Operating Manuals 12
3.3.2 Training 12
3.3.3 Special Tools and Equipment 12
3.3.4 Maintenance Manual 13

3.4 Reserved 13
3.5 Program Management 13
3.5.1 Contractor Work Breakdown Structure (CWBS) 13
3.5.2 Lower Tier Subcontract Management 13
3.5.3 Program Schedule 14
3.5.4 Configuration Management (CM) and Control 14
3.5.5 System Safety 14
3.5.5.1 Safety Analysis 14
3.5.5.2 Material Safety Data Sheets (MSDS) 14
3.5.5.3 On-Site Activities 15
3.6 Quality Assurance 15
3.7 SSCL Numbering System 15
3.8 Units of Measure 15
3.9 Reserved 16
3.10 Management Reviews and Technical Meetings 16
3.10.1 Technical Interchange Meetings (TIM) 16
3.10.2 Technical Reviews 16
3.11 Technical Reports 16
3.12 Cost/Schedule Reports 17
3.13 Interface Control Documents (ICD) 17
4.0 Reserved 17
5.0 Contractor Furnished Property/Services 17
5.1 Contractor Furnished Property 17
5.2 Contractor Furnished Services 17

1.0 SCOPE

This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, install, maintain, and support a prototype Cold Compressor System (CCS), with an option to refurbish the prototype and produce 12 more systems for the Superconducting Super Collider Laboratory (SSCL). A total of thirteen (13) Cold Compressor Systems will be required. Technical requirements are contained in AHW-00002.000, the Technical Specification for the CCS.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in that sector by evaporation. The resulting helium vapor requires compression before returning to the refrigeration plant. The CCS will be located in the cryogenic alcove underground.

The SSCL desires to obtain prototypes of the Cold Compressor to evaluate at the SSCL Cryogenic Test Facility prior to awarding a production option for twelve more systems and refurbishment of the prototype to production configuration. The CCS procurement of the cryogenic systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

SSCL requires a total of thirteen (13) Cold Compressor Systems; ten (10) for the collider main ring, two (2) for the high energy booster (HEB), and one (1) spare. The cold compressor located underground in the accelerator tunnel raises recooler vapor return pressure to surface cryogenic refrigeration plant low pressure. This SOW sets forth the contract requirements for the Cold Compressor Systems.

1.2 OBJECTIVE

The objective of this procurement is to deliver qualified Cold Compressor Modules with accompanying data, spare parts, and training on the schedule required to support collider installation. While URA reserves the right to award all 13 systems to a single subcontractor, it is probable that contracts for the design, development and test of the CCS prototype will be awarded to two subcontractors followed by a down-select to one subcontractor for the production of the twelve systems.

The overall objective is for the subcontractor to deliver Cold Compressor Systems that meet all the performance requirements while providing ease of operation and maintainability for URA over the system life.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the CCS design requirements baseline in the form of a development specification.

b. Present the preliminary design calculations and test methodology at the Preliminary Design Review.

c. Present the product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

d. Prototype build and verification testing.

e. Installation and acceptance testing at SSCL.

f. Maintenance and support of the prototype during evaluation testing at SSCL.

g. Training.

h. Option 1.

- Revise the Technical Data Package as required.
- Fabrication and delivery of the CCS production units.
- Refurbishment of the prototype to production configuration.
- Installation of the first production CCS in an underground tunnel.

Detailed requirements for these tasks are given in Section 3.0 below.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–00002.000 Technical Specification for the Cold Compressor System (CCS)

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. CCS Quality Assurance Plan (to be submitted with proposal)

c. CCS Program Management Plan (to be submitted with proposal)

d. CCS Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Technical Specification for the Cold Compressor System.

3.1 COLD COMPRESSOR SYSTEM DESIGN

The subcontractor shall design Cold Compressor Systems in accordance with the requirements of the Technical Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Section 3.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the CCS. The equipment design shall be fully documented in accordance with the Technical Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Technical Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. For long-lead items the design documentation shall be completed by the time of, and presented at, the Preliminary Design Review (PDR). All other equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted no later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.2 Preliminary Design Review (PDR)

The subcontractor shall conduct a PDR of the Cold Compressor System no later than the date specified in Section F of the Subcontract. The purpose of this review is for URA to assess the progress of the design. As a minimum, the following items shall be addressed:

a. Design Analyses (electrical, mechanical, etc.)

b. System Requirements traceability to the Technical Specification

c. Implementation traceability to the Technical Specification

d. Layout drawings (Level 1)

e. Interfaces

f. Quality control planning

g. Design standardization and logistics

h. Long Lead Item list

i. Fabrication and installation planning

j. Hazard analysis

k Program and near term schedules

l. Program risk assessment

m Problems and concerns

m. Test Planning

o. SSC Test Support

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 3 - Development Specifications)
(CDRL No. 4 - Wiring/Connection Diagram)
(CDRL No. 23- Acceptance Test Plan)
(CDRL No. 5 - Drawings)
(CDRL No. 7 - Reliability Analysis)
(CDRL No. 8 - Failure Modes Analysis)

3.1.2.3 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the Cold Compressor System no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the CCS design has been completed. As a minimum, the following items shall be addressed:

a. Electrical design

b. Mechanical design

c. Interfaces

d. Drawings (Level 2)

e. Specifications

f. Configuration Management

g. Failure modes analysis (FMA)

h. Acceptance Test Planning

i. System safety

j. Prototype Fabrication planning

k. Quality Assurance planning

j. Installation planning

m. Qualification Test Support Planning

n. Logistics

  1. Transportation, packaging, and handling

2. Standardization
3. Special tools and equipment requirements
4. Spares requirements

o. Program and near term schedules

p. Program risk assessments

q. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11– Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on Cold Compressor System performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post–replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 – Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL–STD–490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Technical Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11- Critical Item Fabrication Product Specification (C2b))

(CDRL No. 15-Process Specifications)
(CDRL No. XX - Material Specifications)

3.1.4.2 Drawings

The subcontractor shall convert design requirements to practical design layouts (Level 1) and then convert design layouts to detailed drawings. The subcontractor shall produce all final drawings in a format compatible with DOD–STD–1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 - Drawings)

3.1.5 Prototype Build and Test

The subcontractor shall design, develop, fabricate, procure, assemble, install, maintain and support one prototype Cold Compressor System. This system shall be built to the technical baseline established at the CDR and delivered in accordance with Section F of the Subcontract.

Compliance with the requirements of the Technical Specification shall be verified by the successful accomplishment of the URA approved Acceptance Test Plan, as documented in the URA approved Acceptance Test Report.

(CDRL No. 26- Acceptance Test Report)

3.2 FABRICATION

The subcontractor shall fabricate, assemble, test, package, and ship all components of the CCS, including those fabricated by its subcontractors, in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the CCS Technical Specification and this Statement of Work, in the quantities and to the schedules shown in Section F of the Subcontract. Fabrication requirements delineated in this section shall also apply to any tasks executed in the field as well as those performed in subcontractor facilities. The tasks described in Section 3.2 of this SOW shall be implemented upon exercise of contract option 1.

3.2.1 Design Revision

The subcontractor shall update the technical data package to incorporate any engineering changes to the product baseline, including any recommendations from the URA Evaluation Test Report.

3.2.2 Production Readiness Review (PRR)

The subcontractor shall conduct a PRR of the Cold Compressor System no later than the date specified in Section F of the Subcontract. The purpose of this review is to determine the status of the specific action items which must be satisfactorily accomplished prior to executing a production go-ahead decision. obtain URA concurrence that the specific action items which must be accomplished CCS design has been completed. As a minimum, the following items shall be addressed:

a. Product Baseline review

b. Engineering Change Order review

c. QA Discrepancy Reports

d. Evaluation Test Report recommendations

d. Interfaces

e. Drawings (Level 2)

f. Specifications

g. Configuration Management

h. Fabrication planning

i. Facilities Allocation

j. Long Lead Items

k. Quality Assurance planning

l. Acceptance Test Planning

m. Logistics

  1. Transportation, packaging, and handling
  2. Standardization
  3. Special tools and equipment requirements
  4. Spares requirements

n. Installation planning

o. Program and near term schedules.

p. Program risk assessments

q. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings)
(CDRL No. 11– Product Specifications)
(CDRL No.23 - Acceptance Test Plan)

3.2.3 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.4 Shop Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests of all mechanical, electrical, and electronic equipment, and all instruments and sensors.

b. Final shop pressure and temperature tests and vacuum leak checking.

c. Dynamic balancing of the rotor.

3.2.5 Material Control

The subcontractor shall implement material control procedures in accordance with its CCS quality assurance program and the Technical Specification. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.
(CDRL No. 14 – Parts Qualification Plan)

3.2.6 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the Technical Specification. Such processes include, but are not limited to, welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.
(CDRL No. 15 – Process Specifications)

3.2.7 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the CCS components including all field assembly tasks. Tests required by the Technical Specification and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.3, above, or Section 3.3.4, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 – Fabrication Acceptance Test Plan)
(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in the FTR which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.2.8 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.2.9 Long Lead Items

The subcontractor shall identify long lead items to URA for approval at PDR. The documentation that characterizes the design of all items so identified shall also be provided at PDR.

(CDRL No. 21 – Long Lead Items List)

3.3.10 Installation

The first production CCS shall be installed by the subcontractor in a URA-supplied underground tunnel near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the Technical Specification and in this Statement of Work. This SOW considers installation tasks to be fabrication tasks accomplished in the field; as such, the requirements of Section 3.2 apply.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and inspection of wiring.

3.3 LOGISTICS

3.3.1 Operating Manuals

The subcontractor shall develop an operating manual which fully describes the operation of the CCS in all modes. The operating manual will use indented danger, warning, caution, and note notations to set off and call attention to the severity of potential consequences of human error or mistake. DANGER notation shall be used for situations where death could occur; WARNING shall be used when severe injury or occupational illness could occur; CAUTION notation shall be used for calling attention to a possible less severe consequence of minor injury or minor occupational illness; and NOTE shall be used to explain critical steps where human assembly errors could cause a failure; in addition, NOTE shall be used to set off and call attention to technical information important to the presentation or action being described, thus NOTE is used as a technical notation.

(CDRL No. 35– Operating Manual)

3.3.2 Training

The subcontractor shall conduct a training course for cryogenic engineers and technicians at a Texas location designated by URA. The course shall consist of both classroom and hands–on training. Training shall be completed prior to installation of the first production CCS.

Sufficient information shall be presented to allow operations personnel to perform safe and efficient startup, operation, and shutdown of the CCS. All manual and computer-automated actions required to operate the system shall be described in detail. Training shall include steady state conditions where the process is under control and steps to take when the CCS reaches out of tolerance performance along with emergency steps required to shut down the process.

Maintenance procedures shall be presented including detailed instructions for the maintenance activities that operations personnel may be required to perform and descriptions of all necessary tools and replacement parts. The frequency of scheduled maintenance shall be reviewed. Complete methods used by operations personnel to diagnose equipment failures shall be covered.

At its discretion, URA may choose to record the training on audio and/or video medium for future use.

A training syllabus shall be provided.

(CDRL No. 40– Training Syllabus).

3.3.3 Special Tools and Equipment

After the installation of the first production CCS, the subcontractor shall supply one set of all special tools and equipment required for maintenance.

3.3.4 Maintenance Manual

Prior to installation of the first production CCS, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure.

(CDRL No. 41– Maintenance Manual)

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, logistics, and installation tasks defined by this SOW in accordance with the CCS program management plan referenced in Section 2.3, above. Note that the management tasks of Section 3.5 pertaining solely to design revision, fabrication, and installation shall only be accomplished after the exercise of contract option 1. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the CCS shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contractor Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedule

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver *all* current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address, and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 \ On-Site Activities

All subcontractor personnel shall comply with Section 2.2.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 \ QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the CCS and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA a minimum of ten (10) working days prior to the formal review. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Design reviews (PDR, CDR, PRR) shall be held at the subcontractor's facilities on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST/SCHEDULE REPORTS

The subcontractor shall provide monthly cost/schedule status reports to URA. The cost/schedule information shall evaluate cost performance against contractual deliverables and schedule.

(CDRL No. 31– Cost/Schedule Reports)

3.13 INTERFACE CONTROL DOCUMENTS (ICD)

The subcontractor shall support URA in producing the appropriate interface control document(s).
(CDRL No. 32– Interface Control Documents)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

5.1 CUSTOMER FURNISHED PROPERTY

The SSCL Cryogenics Test Bed (?) will be made available to support Acceptance Testing of the CCS. The (?) will be located in the Cryogenics Building at the N15 Site at SSCL. The (?) will provide the same interface as the SSC Cold Compressor Box. The CCS suction interface will be TBD. The CCS exhaust interface will be TBD. The helium flowrate can range from TBD to TBD, with suction pressures ranging from TBD to TBD. Available power is TBD VAC, TBD Amps, TBD phases, TBD Hz, and TBD VDC, TBD Amps. See Figure TBD for a description of the Cryogenics Test Bed.

5.2 CUSTOMER FURNISHED SERVICES

SSCL will provide the contractor with phone, space for tool storage, instrument calibration lab service, welding shop support, vacuum systems, etc. SSCL will provide power to the CCS power cabinet panel. SSCL will make the cryogenic connection to the CCS. SSCL will unpack the CCS and emplace the CCS equipment on the Cryogenic Test Bed. The Cryogenic Test Bed will provide the following services:

Compressed Air: TBD SCFM at TBD psig
80K Nitrogen: TBD SCFM at TBD psig
Water: TBD gpm at TBD psig
???

TECHNICAL SPECIFICATION

FOR THE

COLD COMPRESSOR BOX

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

APPROVED:

W. FIETZ, HEAD CRYOGENICS DEPARTMENT	DATE	T. KOZMAN, HEAD ACCELERATOR SYSTEMS DIVISION	DATE
J. REES SSCL PROJECT MANAGER	DATE	R. SCHWITTERS SSC LABORATORY DIRECTOR	DATE

PREPARED BY:

J. LOBB DATE
CRYO PLANNING & DEVELOPMENT

REVIEWED:

D. EVANS, LEADER DATE
CRYO PLANNING & DEVELOPMENT

R. LUTHER, LEADER DATE
CRYO MECHANICAL ENGINEERING

D. HAWKINS, HEAD DATE
ASD SAFETY

J. WENTZ, HEAD DATE
ASD QUALITY ASSURANCE

Table of Contents
Cold Compressor Box Specification

1.0 Introduction and Scope
2.0 Applicable Documents
    2.1 Drawings Furnished by URA
    2.2 Standards
        2.2.1 Industry and Society Documents
        2.2.2 SSCL Documents
        2.2.3 Government and military Documents
3.0 Requirements
3.1 General
    3.1.1 Reliability
    3.1.2 Maintenance
    3.1.3 Maintainability
    3.1.4 Services Restrictions
        3.1.4.1 Instrument Air
        3.1.4.2 LN2
        3.1.4.3 Electrical
    3.1.6 Mechanical
        3.1.6.1 Design Pressures
        3.1.6.2 Leak Rates
        3.1.6.3 Weights and Measures
        3.1.6.4 Pipework
        3.1.6.5 Materials
        3.1.6.6 Welding
        3.1.6.7 Cleaning and surface treatment
        3.1.6.8 Lifting, Maneuvering
    3.1.7 Electrical
        3.1.7.1 Enclosures
        3.1.7.2 Terminal blocks
        3.1.7.3 Wiring, cables and connectors
        3.1.7.4 Color codes
        3.1.7.5 Connectors
        3.1.7.6 Cable identification
        3.1.7.7 Wire identification
        3.1.7.8 Grounding
3.2 Process
    3.2.1 Design Mode
    3.2.2 Nominal Mode
    3.2.3 Standby Mode
3.3 Cold components
    3.3. Cold piping
    3.3. Heat exchanger
    3.3. Phase separator
    3.3. Cryogenic valves
    3.3. Valve Actuators
    3.3. Filters
    3.3. Relief valves
    3.3. CCM Bayonets
    3.3. Vacuum barriers
    3.3. Radiation shield
    3.3. MLI Multilayer Insulation
        3.3. Material
        3.3. Application
    3.3 Thermal Intercepts

3.4 Warm components
- 3.4.1 Vacuum Enclosure
- 3.4.2 Vacuum pumping
  - 3.4.2.1 Pumps
  - 3.4.2.2 System
- 3.4.3 Valves
- 3.4.4 Relief Valves
- 3.4.5 Joints and seals

3.5 Instrumentation
- 3.5.1 Cold Box
- 3.5.2 Vacuum System

3.6 Interface with SRC
- 3.6.1 Physical
- 3.6.2 Sensors and transmitters
  - 3.6.2.1 Pressure sensors
  - 3.6.2.2 Temperature sensors
- 3.6.3 Units

3.7 Environment, safety and health
- 3.7.1 Hazardous chemicals

4.0 Quality
- 4.1 Reliability
- 4.2 Mean down time
- 4.3 Availability
- 4.4 Maintainability

SSC Laboratory
Cold Compressor System RFI

1.0 Introduction and Scope

The Supercollider has 12 distributed surface refrigeration systems. Each of these provides cryogens to local tunnel superconducting magnets via a Cold Compressor Boxe (CCB).
Process interfaces with each CCB are:

a transfer line from surface refrigerator containing:
LN2 liquid supply
LN2 vapor return
4bar liquid Helium supply
3.5 bar liquid helium return
20K helium
6K helium return

b transfer line to the Tunnel Distribution Box located adjacent to the CCB containing:
LN2 liquid supply
LN2 vapor return
4bar liquid Helium supply
3.5 bar liquid helium return
20K helium
4K helium vapor return

c supply and return to the Cold Compressor Module (CCM). The CCM process inlet and outlet are bayoneted into the CCB. There is provision for an additional CCM for future upgrades.

This Request for Information specification previews URA requirements for Cold Compressor Boxes. Comments are solicited from contractors to aid in preparation of the Request for Proposal (RFP).

2.0 Applicable Documents

2.1 Drawings Supplied by URA

- 2.2-1 SSCL Main Accelerator Ring Plan View
- 2.2-2 Sector Refrigerator System Block Diagram
- 2.2-3 Cold Compressor Box schematic
- 2.2-4
- 2.2-5 Flow/Pipe/Component Symbols

2.2 Standards

The Contractor proposal shall list all applicable standards to be used in the design, construction, test, packaging and shipping. The following documents of the exact issue shown form a part of this document to the extent specified herein. If a conflict arises between the documents referenced below and the contents of this specification, the latter shall prevail.

2.2.1 Industry and Society Documents

a) American National Standards Institute (ANSI)
   1) ANSI/ASQC Q91-1987 , Quality Systems-Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

b) American Society of Mechanical Engineers (ASME)
   1) Petrochemical Plant and Petroleum Refinery Piping B31.3.
   2) Building Services Piping B31.9.

c) National Electrical Code (NEC)
   1)
   2)

d) National Electrical Manufacturers Association (NEMA)
   1) Stds. Publication No. PR 4: Plugs, Receptacles and Cable Connectors of the Pin and Sleeve Type for Industrial Use.
   2) Stds. Publication·No. 250: Enclosures for Electrical Equipment (1000 Volts Maximum)

e) International Standards Organization (ISO)
   1) ISO1000, (units)

d) Compressed Gas Association (CGA)
   1) CGA 341, Standard for Insulated Cargo Tank Specifications for Cryogenic Vessels—3.6 General Requirements, Outer Shell.

2.2.2 SSCL Documents
   1) P40-000119.A, Leak checking
   2) P40-000120.A, Processing of Stainless Steel Weldments for High Vacuum Use
   3) AQA-1010097.0, Contracted Supplemental Welding and Brazing.

2.2.3 Government / Military Documents
   3) MIL-STD-130, Identification Marking
   4) DOD-STD-1000B, Drawings, Engineering, and Assembly Lists.
   5) Ocupational Health and Safety Act, 29 CFR Part 1910, OSHA Standards
      Specific items to be listed by contractor during design stage.

3.0 Requirements

3.1 General

3.1.1 Services Restrictions

3.1.2.1 Instrument air

The system shall require no external services apart from electrical power and 100 psig (6.9 bar) instrument air (see 6.??)

3.1.2.2 LN2

3.1.2.3 Electrical

Phase, Frequency,Voltage, Current limitation

3.1.6 Mechanical

3.1.6.1 Design Pressures

Containment design pressure shall conform to the requirements in table ???

Table ???

Line	interconnection from/to	Design Pressure bar
4bar liquid		
3.5bar liquid		
4K vapor		
6K		
80 K liquid		
80 K vapor		
20K supply		
20K return		

3.1.6.2 Leak Rates

Leakrates measured according to SSCL Document P40-000119.A00 shall be as follows:

1	To Vacuum from Helium/Nitrogen	
	Plate fin heat exchanger	<1x10-6 mbar l/s
	Piping, vessels, and valves	<1x 10-9 mbar l/s.
2	To Vacuum from Atmosphere	
	Atmosphere to vacuum	<1x10-6 mbar l/s
	Demountable seals	<1x10-7 mbar l/s
	Vacuum pump (Integrated)	<1x10-5 mbar l/s
3	To Atmosphere from Process (pressure above 1 bar)	
	Relief valves (new)	<1x10-7mbar l/s
	Relief valves after repeated use (20 times)	<1x10-2 mbar l/s
	Demountable seals	<1x10-7 mbar l/s
	Integral leak rate (excluding relief valves)	<1x10-5 mbar l/s.
4	From Atmosphere to Process (pressure below 1 bar)	
	Relief valves after repeated use (20 times)	<1x10-6 mbar l/s
d.	Integral leak rate	<1x10-5 mbar l/s.
	Demountable seals	<1x10-7 mbar l/s
	Cryogenic valve stems	<1x10-7 mbar l/s
5	Process/Process Leakage	
	Valve seat	
	Heat exchanger cross	<1x10-4 mbar l/s

Subcontractor shall submit leak-checking procedures before construction begins.

The system shall be designed for no vacuum loss due to air leakage over a period of twelve (12) months for operating and non-operating conditions.

Under normal operating conditions, the coldbox shall be able to maintain a pressure less than 1¥10–7 mbar, preferably as static vacuum. This is not to be confused with the allowable internal leakage rate of less than 10-5 mbar-liter/s.

3.1.6.3 Weights and Measures

Maximum dia	
Max height	
Vacuum enclosure	
Projections	
CCB bayonet interface	
Max weight	TBD kg (TBD lbs)
Floor loading	TBD kg/cm2 (TBD psi)
Transfer line interface projection	
To shaft	
To distribution box	

3.1.6.4 Pipework

3.1.6.5 Materials

a Proven items shall be used where possible. The number of original components and assemblies shall be minimized.

b All material and equipment must be new and suitable for the application.

d All devices such as instruments, valves, and filters shall allow for convenient inspection and maintenance.

g The selection and combination of materials exposed to atmosphere shall be such that no significant galvanic corrosion can occur.

k All system piping shall conform to ASME B31.3.

l All general use warm piping (above 270 K), shall be austenitic stainless steel, seamless or welded, ASTM A312 pipe.

h. Rubber and plastic hoses, pipe, and fittings shall not be used on helium, nitrogen or vacuum circuits.

j The use of epoxies or other similar materials shall require prior approval of URA.

3.1.6.6 Welding

Welding shall comply with the requirements of:

ASME B31.3.
SSCL Document P40-000120.A
SSCL Document AQA-1010097.0

3.1.6.7 Cleaning and Surface Treatment

a Cleaning of internal surfaces of piping (including field-installed piping) vessels, valves, and devices shall meet requirements for normal refrigeration/cryogenic equipment not exposed to liquid air or oxygen, per ASTM A 380-88. The contractor shall submit detailed cleaning procedures before construction starts.

b All flux residue from brazed or soldered connections, all weld spackle and slag, and all sand and other particulates shall be removed. Systems shall be drained and purged of all solvents and be thoroughly dried.

c Visual inspection under bright and black light shall indicate no moisture, rust, foreign matter, film, or accumulation of oil, grease, or paint.

d Cleaned internal surfaces shall have sufficient protection to maintain established cleanliness.

e All carbon-steel surfaces exposed to atmosphere shall be sand-blasted. The contractor shall then apply one (1) shop coat of rust-inhibitive primer and two (2) 50 microns (0.002") shop coats of enamel (dry film thickness). Color scheme will be given by URA after design approval.

3.1.6.8 Lifting, Maneuvering

3.1.7 Electrical

3.1.7.1 Enclosures

a All enclosures shall be NEMA 12 standard.

b. Enclosures shall be located for access from a normal work surface and have an electrical hazard decal located on the door

c Enclosures shall house only electrical and/or fiber optic devices.

3.1.7.2 Terminal blocks

a The terminal blocks of the electric cabinets shall have a reserve of at least 10% spare terminal points.

b Terminal points shall be numbered on the terminal block, and each terminal block shall be numbered.

c All terminal blocks shall be rated for the highest voltage present on that terminal block.

3.1.7.3 Wiring

a All wiring shall be installed in a good and workmanlike manner, suitable for the environment in which it is installed, and shall conform to NEC Article 300.

b All wiring shall meet UL VW-1 Vertical Flame Test.

c For all applications above 250 K, the contractor shall use stranded copper wire with suitable insulation for the application. For all applications below 250 K, the contractor shall use stranded copper wire with PTFE insulation unless noted elsewhere in this specification. Field instrumentation wiring shall be shielded cables of twisted pairs, twisted triples, or twisted quads. Exceptions must be approved by URA.

d Both ends of all cables and conductors shall be labeled according to a logical labeling scheme (see Sections 3.6.7.4 and 3.6.7.5). Wires not soldered to plugs or sockets shall be terminated at a terminal point. Spare wires or cables shall not be left loose.

e Plugs, sockets, and terminals shall be wired according to the electrical elementary through the entire system.

f. Plugs and sockets shall be rugged industrial type with strain relief clamp and quick coupling which can be bayonet or other locking system. Soldered—or, preferably, crimped—gold plated pins shall be used. In case identical connectors are selected for different functions, the socket and plug insert shall be keyed at different angles.

g. The socket end of a connector shall always be the powered end.

h. Connectors at more than 30C (50F) below ambient shall be hermetically sealed to prevent condensation wetting of the connection.

i. Wire ties are not permitted inside conduit, cable tray, or wiring duct.

j. Analog signal cable shall be physically separated from other types of control and power cable.

k. No more than two wires per terminal point shall be permitted .

l. The contractor shall ground all equipment, per NEC Article 250, to the system ground that is supplied by URA.

m. All shielded cables shall be grounded on one end only. All shielded cables that do not enter the interface rack shall have their shields connected to a common point (insulated from equipment ground) and that point shall be connected to the URA supplied instrument ground.

3.1.7.4 Color codes

a. Three-phase wiring shall be color coded as follows:

Phase 1 Brown
Phase 2 Orange
Phase 3 Yellow
Neutral Gray
Ground Green

On the larger size wires that are not available with color-coded insulation, the contractor shall use 1" wide colored tape to color code the wire at the terminal end.

b. Control and single phase power shall be color coded as follows:

ac line voltage Black
ac control voltage RED
ac neutral WHITE
dc control BLUE
Ground GREEN
External source YELLOW

On the larger size wires that are not available with colored coded insulation, the contractor shall use 1" wide colored tape to color code the wire at the terminal end.

c. Multiconductor cable color code shall be the cable manufacturer's standard color code.

3.1.7.5 Connectors

a. All crimp connectors shall be installed with a ratchet type crimping tool.

b. All crimp connectors shall be of the insulated type for wires AWG #10 and smaller, except where noted.

c. Devices with pigtail connections shall be connected utilizing a bolted splice and insulated with a minimum of three layers of electrical tape.

d. Crimp type wire splices are not permitted.

e. Plugs and receptacles shall comply with standards set out in NEMA Stds. Publication No. PR 4.

3.1.7.6 Cable identification

a. Cable marking shall be of the wrap type marker with a clear heat shrinkable sleeve to protect the marker.

b. Cable numbering shall be in a format of XXX-XX-XXX; as in the following table:

First group	Site location (N15, N25, etc.)
Second group	Equipment type (CC = cold compressor, etc)
First digit of third group	Cable type (P = power, C = control, A = analog)
Remaining digits of third group	Cable number (1, 4, 10, etc.)

For example, cable number N25-CC-1A4 would be a cable at site location N25, equipment type Cold Compressor # 1, an analog signal, the fourth cable in a series of analog cables for Compressor # 1.

3.1.7.7 Wire identification

a. Wire markers shall be of the heat shrinkable sleeve type.

b. Wire numbers shall be a four-digit number. The first two digits shall indicate the sheet number of the elementary, and the second two digits shall indicate the wire on that sheet.

3.1.7.8 Grounding

All electrical equipment shall be grounded in accordance with NEC 250 and have overcurrent protection in accordance with NEC 240.

3.2 Process

The CCB performance shall meet the mode process requirements given in tables ??? thru ???

Table ???.1

3.2.1 Design Mode

Design Mode

Line	intercon from/to	T1 K	P1 bar	m g/s	_H j/gm	_P mbar
4bar liquid						
3.5bar liquid						
4K vapor						
6K						
80 K liquid						
80 K vapor						
20K supply						
20K return						

Table ???.2

3.2.2 Nominal Mode

Line	intercon from/to	T1 K	P1 bar	m g/s	_H j/gm	_P mbar
4bar liquid						
3.5bar liquid						
4K vapor						
6K						
80 K liquid						
80 K vapor						
20K supply						
20K return						

Table ???.3

3.2.3 Standby Mode

Line	intercon from/to	T1 K	P1 bar	m g/s	_H j/gm	_P mbar
4bar liquid						
3.5bar liquid						
4K vapor						
6K						
80 K liquid						
80 K vapor						
20K supply						
20K return						

3.3 Cold components

3.3.1 Cold piping

With the exception of the heat exchanger, all internals shall be fabricated from 304 stainless steel.

All cold/cryogenic piping (less than 270 K) shall be per ASTM A312 with 304, 304L, 304LN or 316 material.

Seamless pipe may be used for all applications.

The layout of cold piping shall be designed to prevent the occurrence of thermal acoustic oscillation and to minimize convective instabilities. Particular attention should be paid to piping, valving, and penetrations which may be subject to very high thermal gradients.

The layout and support of cold piping and components shall allow for thermal contraction without generation of excessive stresses.

The heat leak load associated with the cold piping shall be properly accounted for in the design

All bayonets shall be installed in vertical position, with the male section pointing down.

All transition joint assemblies shall be 80 K shock, pressure, and leak tested after installation in cold piping. In addition, all transition joint manufacturer's test documentation, including lifecycle tests or records, shall be submitted to URA.

Any installed joints or welds for temperature service less than 270 K shall be designed for 10,000 temperature cycles from 400 K to 4 K without loss of vacuum integrity.

All joints which form a barrier to helium gas leakage into the vacuum space shall be welded. There shall be no demountable joint under these conditions without the written approval of URA.

3.3.2 Heat exchanger

1. The heat exchanger shall be mounted vertically and with warm end up.
3. The plate-fin heat exchanger shall be vacuum furnace brazed and cleaned of foreign material prior to coldbox installation. (How TBD).

Description Units Equip. Remarks
Design Design
HX Performance
(for each heat exchanger and each stream)
Inlet temperature stream K
Outlet temperature stream K
Inlet pressure stream bar
Outlet pressure stream bar
mass flow of the stream g/s
Fin code with definitions
Primary surface area (A1) m^2
Secondary surface (fin) area (A2) m^2
Total surface area (A=A1+eA2) m^2
Free flow cross sect. area of core mm^2
Flow length of core m
Mass velocity g/s-m^2
Reynolds No.
"Coleburn ""j"" factor (define)"
Heat transfer coefficient kW/m^2-K
"Friction factor ""f"" (Define)"
Pressure drop heat exchanger core mbar
Pressure drop HX inlet distributor mbar
Pressure drop HX exit distributor mbar
Pressure drop HX inlet nozzle mbar
Pressure drop HX exit nozzle mbar
DP total for this stream in the HX mbar

For Each Heat Exchanger
Heat leak in to the heat exchanger W
Total energy transferred kW
Integrated MTD over cooling curves K
Cmin/Cmax
UA required for process duty kW/m^2-K
UA req. for longitudinal conduction kW/m^2-K
Total UA required kW/m^2-K
Total UA Provided kW/m^2-K
NTU's required for process duty
NTU's req. for longitudinal conduct'n
Total NTU's required
Total NTU's provided
Effectiveness required
Effectiveness provided

3.3.3 Phase separator

The phase separator shall be _TBD mm (_TBD inches) diameter.

Overall length shall be _TBD mm (_TBD inches).
Vessel ends shall be TBD.

Volume
solids removal
liquid removal
liquid vaporization
heater

3.3.4 Cryogenic valves

b. Cold valves (without LN2 heat intercept) in any helium system shall not exceed heat leak from ambient temperature to 4 K given in table ????

Table ???

Valve Size	Heat Leak
(inches)	[W]
1/2, 3/4, 1	< 1.5
1-1/2	< 2.5
2	< 3.0
3	< 5.0
4	< 7.0

c. All cold valves for helium service shall incorporate a stainless-steel sealed bellows, a double seal, and a sample port for leak-checking the shaft spindle interspace.

The valve plug shall be removable, and it shall be possible to repair the seat in situ if it is not removable.

h. All valve seals and trims shall be soft seat and, together with control plugs, shall be easily replaceable.

i. All valves except hand valves shall have a fail-safe position.

Valves shall be designed to prevent thermal-acoustic oscillations.

Table ????

Valve	interconnection from/to	pressure bar	Cv

3.3.5 Valve Actuators

3..3.5.1

3.3.6 Filters

All filters shall be replaceable from the outside of coldbox vessels without breaking vacuum.

Filter materials shall be compatible whti cryogenic operation and shall be capable of full process reverse flow.

The nominal inlet side of the filter shall be provided with a low velocity annular volume of TBD pipe diameters radius and TBD pipe diameters deep in which particulate can collect when it is dislodged from the *filter surface during reverse flow.*

The filter removable assembly shall be provided with soft seals to the filter housing, and the seals shall be resiliantly loaded. Cryogenic seal leakage measured at 80K and 1 atmosphere shall not exceed 1 l/min (0.035 SCFM).

Seals shall be replaceable and of commercially available design.

Woven wire filters shall be capable of being cleaned of all particulate by solvent washing.
Fabric filters shall be easily replaced.
Design pressure drop for the filter material shall be 0.5 bar (7.25 psi) in both directions.
Filters shall be designed to prevent thermal-acoustic oscillations.
Filter performance and surface area shall conform to the requirements listed in table ???

Table ???

Item	interconnection	Min. Area	Performance *	Heat Leak **	Pressure
	from/to	cm2 (inch2)	microns	[W]	bar

* Performance is expressed as the absolute Efficiency Rating (i.e. 99.99% removal of tabulated particle size)
** Without LN2 heat intercept.

3.3.7 Relief valves
All safety relief valves shall be UL approved.
All relief valves shall be accessible for inspection and resetting.
All pressure relief devices shall be accessible for servicing and heating with a hot-air blower.

Table ???

Valve	interconnection from/to	pressure	Cv

3.3.8 Bayonets
a The enclosure shall have female process inlet and outlet bayonets extending vertically downwards.
b Full Bayonet specifications and designs will be provided by URA with the RFQ.
Current designs require a minimum 12 inches (305 mm) and maximum 20 inches (508 mm) between male bayonet centers at the cold compressor box. The heat break length will be 30 inches (762 mm) minimum.
c Tolerance on bayonet mutual position and angularity:
Mutual angular displacement: >20
Center to center distance: >0.040 inches (1.0 mm)
d The Cold Compressor Box the connection shall be robust enough that it can carry the assembled weight of the Cold Compressor Module (CCB). In addition the support shall sustain a twisting torque resulting from rotating mass stored energy in Cold Compressor seizure.
Stored energy is estimated to be TBD joules, and the duration of failure TBD secs.
a. The vacuum enclosure shall have a rigid standoff flanged to receive a 4" Worcester ball valve (type ???) for bayonet isolation.

3.3.9 Vacuum Barriers

3.3.10 Radiation shield

The designed maximum radiation shield temperature shall be TBD.

The shield shall enclose all cold piping with the exception of penetrations and transfer line pipes. Liquid nitrogen and nitrogen vapor lines may be enclosed.

The radiation shield shall be cooled with liquid nitrogen gravity fed from a liquid nitrogen reservoir. Vapor shall be returned to the transfer line 80 K return.

3.3.10 Liquid Nitrogen Reservoir

The reservoir internal dimensions shall be _ 135 mm (5.31 inch) diameter x _ 540 mm (21.3 inch) long.

Vessel ends shall be TBD.

Liquid supply shall be taken from the transfer line 80 K line I, and level shall be controlled by TBD.

Vapor from the reservoir shall be returned to the transfer line 80 K return.

3.3.11 MLI Multilayer Insulation

The helium components and the inner side of the coldbox vessel shall be super-insulated.

3.3.11.1 Materials

a The substrate and reflector shall be prepared to Fermi National Laboratory Specification ES-239972.

b Separation of reflector layers shall be by spun bound PET sheet.

c Where necessary insulation shall be secured with adhesive aluminium tape.

3.3.11.1 Application

a Surfaces shall be covered as follows:

Nominal 4 K TBD layers
Nominal 20 K 32 layers
Nominal 80 K 64 layers

b Layer density shall be 60 to 80 layers per inch. Where convenient MLI shall be applied in 4 or more butting blankets as shown in fig ???. The joins in successive blanket layers shall be separated by 180^0 or 100 mm (4 inches).

3.3.12 Thermal Intercepts

All penetrations of cross section area to length ratio _TBD from above 270K to _ nominal 20K shall have thermal interception to the 80K radiation shield. Unless otherwise stated the intercept shall be thermally anchored at mid point between substantially isothermal ends of the penetration. The heat conductor shall be braided copper wire with an effective cross section area to length ratio _TBD. Attachment at each end shall ensure good thermal contact.

Table ???

Item	Penetration

3.4 Warm components

3.4.1 Vacuum Enclosurec

Except for the top plate or head, which shall be stainless steel, the coldbox vessels may be constructed of carbon steel. The outer and inner surface of the carbon steel vessel shall be painted in accordance with ???.

The enclosure shall be fabricated in accordance with CGA 341.

The vacuum enclosure shall be designed for a sustained maximum pressure of <1x10-3 mbar over a period of twelve (12) months for operating and non-operating conditions.

All vacuum vessel penetrations shall be designed such that the temperature of any point on the surface of the vessel is within 5°C of ambient temperature. The penetrations shall also allow for thermal movement over the entire operating temperature range.

3.4.2 Vacuum Pumping

3.4.2.1 Pumps

An active, dedicated vacuum system consisting of an oil lubricated roughing pump and turbomolecular pump shall be provided, and shall be of adequate size for a pump-down within 48 hours from utility vacuum pump-down pressure level to 1¥ 10-5 mbar or better with all internal components fully outgassed and at ambient temperature.

The minimum pumping speed for this pump shall be greater than TBDl/sec for helium and the vacuum pump port shall be a minimum of TBDmm (TBD in) diameter.

The roughing pump shall be shock-mounted to minimize vibration coupling with the Adit structure. The output vibration estimate shall be supplied to URA at the time of the proposal. The vacuum pumps shall be air cooled.

Back diffusion of hydrocarbons to the vessel vacuum space shall be _TBD.

3.4.2.2 System

Vacuum-vessel pressure gauges shall be located on the vacuum vessel at a right angle to the pump port at the vessel top plate. The vacuum pumping system minimum requirements are shown in Figure 3.2.1-B.

Robust screens shall be provided on the vacuum side of the pump out port to limit the hazard of blockage by superinsulation. The screen projected area shall be no less than 4 x port area.

A vacuum gate valve shall be installed between the coldbox and its vacuum system, to close in the event of power outage and to allow the replacement of vacuum system components without breaking the coldbox vacuum. The coldbox, the gate valve, and the pump shall be closely coupled for maximum pumping speed.

Connections in vacuum system shall be metallic rigid tube or flexible bellows.

In case of failure of controls, power, or instrument air, or failure of any component of the vacuum system, vacuum the gate valve shall close and the roughing and high vacuum pumps shall be shut down.

If the vacuum vessel pressure rises above 1¥ 10-1 mbar, the high vacuum pump shall be shut down and isolated automatically and the roughing pump shall be valved into the vessel.

3.4.3 Valves

3.4.4 Relief valves

All manual service valves shall be collected in a few convenient locations and clearly labeled as to function.

All valves shall be stamped with flow arrows on the body.

Valves shall be installed with flow arrows orientated towards the lower pressure at operating condition.

All valves up to 10 mm shall be bellows sealed.

Instrument valves shall be standard single seal bellows type.

All valves on 0.75 bar/4 K helium and 1.4 bar/1.4 K helium circuits shall be bellows sealed.

Valves with packed sealing system need the approval of URA.

Lines to isolation valves shall have thermal stabilization loops for no-flow conditions.

3.4.5 Joints and Seals

All seals, joints, and welds must be double acting, holding pressure as well as vacuum.

Soft and hard soldering may be used for electrical connections only.

Brazing may be used only for a limited number of transition joints (copper/stainless steel) and standard item electric heaters. If extensive brazing procedures are proposed, the Brazing Procedures Specifications (BPS) and Brazing Qualification (BQR) shall be submitted with the proposal.

All detachable joints (such as at flanges, ports, bayonets, and valves) shall have all-metal seals or O-ring seals. The required surface finish for O-ring seals with elastomer gaskets must be better than 1.5 mm rms, and for all metal seals better than 0.3 mm rms.

The design and construction of demountable seals shall be such that the joint can be broken and reestablished at least 20 times without damaging the sealing surfaces.

Demountable joints forming a seal between helium and atmosphere shall be O ring sealed. There shall be no compressed gaskets, compression fittings or thread sealants. The required surface finish for O-ring seals with elastomer gaskets must be better than 1.5 microns rms, and for all metal seals better than 0.3 mm rms.

Small couplings (up to 10 mm) for service at more than 270 K in helium pipework and at connections to valves and instrumentation shall be Parker UltraSeal, Cajon VCO or equivalent zero clearance fittings commercially available in the USA. Compression fittings are not acceptable for helium service.

3.5 Instrumentation

3.5.1 Vacuum System

For details of the minimum requirements, see Table 3.9.???

Table ??

Local	Remote	Description
X	X	Vacuum vessel pressure (low vacuum)
X	X	Vacuum vessel pressure (high vacuum)
	X	
	X	
X	X	Turbo pump foreline pressure
	X	Forepump inlet pressure

3.5.2 Coldbox

For details of the minimum requirements, see Coldbox, Figure Table 3.9.???

Table ???

Local	Remote	Description
	X	CB HX-1A 1 or 2 VN2 inlet temperature
	X	CB HX-1A 1 or 2 VN2 inlet pressure
	X	CB HX-1A 1 or 2 VN2 mass flow
	2X	CB HX-1A 1 and 2 GN2 outlet temperature
	2X	CB HX-1A 1 and 2 GN2 outlet pressure
	X	CB HX-1C LN2 inlet to phase separator pressure
	X	CB HX-1C LN2 inlet to phase separator temperature
	X	CB HX-1C LN2 inlet to phase separator mass flow
	X	CB HX-1C LN2 phase separator level
	X	CB HX-1C LN2 phase separator pressure
	2X	
	2X	CB HX-1A 1 and 2 HP helium inlet temperature
	2X	CB HX–1AB 1 and 2 HP differential pressure
	2X	CB HX-1B 1 and 2 HP outlet helium temperature
	2X	CB HX-1B 1 and 2 MP inlet helium temperature
	2X	CB HX-1A 1 and 2 MP helium outlet pressure
	2X	CB HX-1A 1 and 2 MP helium outlet temperature
	2X	CB HX-1A 1 and 2 MP helium outlet bypass flow
	2X	CB HX-1A 1 and 2 - 20 K helium outlet pressure
	2X	CB HX-1A 1 and 2 - 20 K helium outlet temperature
	2X	CB HX-1A 1 and 2 LP helium outlet pressure
	2X	CB HX-1A 1 and 2 LP helium outlet temperature
	X	CB HX-1C HP outlet helium pressure
	X	CB HX-1C HP outlet helium temperature
	X	CB 80 K adsorber HP outlet helium pressure
	X	CB 80 K adsorber HP outlet helium temperature
	X	CB HX-1B 1 or 2 MP helium inlet pressure
	X	CB HX-1B 1 or 2 MP helium inlet temperature
	X	CB HX-1B 1 or 2 - 20 K helium inlet pressure
	X	CB HX-1B 1 or 2 - 20 K helium inlet temperature
	X	CB HX-1B 1 or 2 LP helium inlet pressure
	X	CB HX-1B 1 or 2 LP helium inlet temperature

3.6 Interfaces with Sector Refrigerator Control (SRC)

3.6.1 Physical

a. The physical interface between the Sector Refrigerator Control (SRC) and the Local Control Center (LCC) will be at the URA interface rack located at Adit level and separated from the Cold Compressor Box by approximately 100 ft (30m).

The contractor shall provide all interconnections between the interface rack and LCC.

b. URA will assign all terminal points in the interface rack. The procedure for assigning the interface rack terminals will be as follows:

1. The contractor shall draft the electrical elementary showing the connections to the interface rack using a symbol such as a triangle. Sufficient space shall be allocated to the right of the symbol for the URA supplied terminal number.
2. The contractor shall then submit the drawings to URA for approval.
3. Upon receiving these drawings, URA will determine according to the architecture of the control system the exact location that each wire shall be connected to in the interface rack.
4. URA will return a copy of the marked-up electrical elementary to the contractor for the incorporation of the URA supplied interface terminal numbers.

3.2.6.1.2 Electrical Interface/Signal Conditioning;

a. All analog signals to and from interface rack shall be linear.

e. The sensor output to the interface rack can be linear, nonlinear, continuous, or pulsed, but shall conform to Section 3.2.6.1.2.

b. Signals shall be conditioned as follows:

1. All analog signals from contractor equipment to URA control equipment shall be source 4-20 mA. The electrical specifications for the URA analog input modules are as follows:

o Type of input Analog
o Rated voltage 20–28 V dc
o Input current range 4-20 mA
o Input resistance 500 ohms

2. All analog signals from URA control equipment to contractor equipment will be source 4-20 mA. The electrical specifications for the URA analog output modules are as follows:

o Type of output Analog
o Rated voltage 20–28 V dc
o Output current range 0–20 mA
o Max. loop resistance 600 ohms

3. All digital signals from contractor equipment to URA control equipment shall be +24 V dc "true." The electrical specifications for the URA discrete input modules are as follows:

o Type of input: Discrete
o Rated voltage 24 V dc
o Operating voltage range 0–30 V dc
o Voltage range for "ON" 14.0–30 V dc
o Voltage range for "OFF" 0.00–5.0 V dc
o Input current for "ON" 2.0–15.0 mA
o Input current for "OFF" 0.5 mA

4. All digital signals from URA control equipment to contractor equipment shall be + 24 V dc logic "true" rated at 0.5 A. The electrical specifications for the URA discrete output modules are as follows:

o Type of output Discrete
o Rated voltage 6–24 V dc
o Operating voltage range 4.5–34 V dc
o Temporary overload 2.0 A for 1 ms
o Max. "ON" state voltage drop 1.8 V dc
o Max. "OFF" state leakage current 0.2 mA

Where special equipment signal levels do not conform to this listing, the contractorshall supply interface electronics to convert to the standard process signals shown. This interface electronics will be subject to URA approval. Any signal different from the standard signals defined here is subject to URA approval.

c. All device malfunctions shall produce a signal logic "false." Normal operation within accepted limits shall produce logic "true."
d. Signal conditioning units shall be installed in a contractor-supplied AMCO #8211 rack, which shall be married to the URA-supplied interface rack (see Section 3.2.5.1.1).
e. Signal conditioning units shall be located within those stations.

3.6.2 Sensors and Transmitters

a. The CCB shall be equipped with sensors as necessary to provide for its safety and protection, and manual and automatic remote-controlled operation.
b. All sensor outputs shall be connected to the LCC for remote monitoring and data acquisition at the SRC. The minimum sensor monitoring requirement is given in 3.2.6.5.
c. All sensors may be state of the art but must have proven reliability, accuracy, reproducibility, long time stability, and maintainability. Sensors shall have a past history of at least 20,000 hours of continuous operation in a similar application. Sensors that do not meet this requirement shall not be used without prior URA approval.
d. Sensor signal dependence on ambient temperature and cable length shall be minimized.
e. The sensor output to the interface rack can be linear, nonlinear, continuous, or pulsed, but shall conform to Section 3.2.6.1.2.
f. All sensors shall be labeled with a permanent tag, numbered as shown on the P&IDs.
g. All sensor installations shall allow for easy replacement of the sensor without opening helium circuits or vacuum spaces to atmosphere. Redundant sensors shall be installed at all points where replacement is difficult. All spare redundant critical control point sensors shall be connected to the URA interface rack.
h. Loop response time shall be less than .05 sec from sensor input to interface.

3.6.2.1 Pressure Sensors

a. Pressure and vacuum instrumentation such as pressure transducers and vacuum gage tubes shall have an isolating valve to facilitate replacement, servicing, or recalibration.
a. All process points are measured as static pressures. Wall tap shall be 4 mm or smaller in diameter, with a sharp, burr-free edge, installed normal to flow boundaries in straight tube or pipe sections. Combined pressure/temperature taps are not acceptable.
b. Pressure sensor connections shall be made with stainless steel tubes of 4 mm inside diameter. Each line between process point and sensor (both low and high pressure lines in case of a differential pressure sensor) shall be equipped with a loop for vibration isolation and thermal stabilization, and shall have an isolation valve. Differential pressure sensors shall also have a bypass valve unless misuse of the bypass valve could cause contamination of the system.
c. Valved test ports shall be installed on all pressure sensors.
d. VCO style fittings shall be used on pressure sensing lines and test ports.
e. Unless the difference of two process points is measured, all pressure measurements shall be absolute.
f. Pressure sensors shall be capable of withstanding pressures to 150% of the maximum rated system pressure or 2 bar over the sensor's relief valve setting, whichever is greater, without requiring recalibration.
g. Pressure sensors shall not be mounted inside the coldbox vacuum.
c. Pressure sensor loop accuracy shall meet or exceed the following full-scale specifications:

Accuracy	± 0.5%
Sensitivity	0.1%
Repeatability	0.1%
Stability	± 0.1%/yr

3.6.2.2 Temperature Sensors

The subcontractor shall use 4-wire silicon diodes. Thermocouples are not acceptable.
1. With the exception of real surface temperature measurements (e.g., heater protection, heat exchanger body temperature), all process temperature sensors shall be mounted in thin stainless steel wells which extend to the center of the pipe.
2. The sensor shall be mounted on the bottom of the well. Vacuum grease or indium metal shall be used between the sensor and the mounting surface. The well diameter shall be slightly greater than the sensor dimension to allow easy sensor installation or changeout. The thickness of stainless steel between the sensor and process stream shall be minimized. The surface of the well contacting the process stream may be finned.

3. At least 1 m of the sensor cabling at the sensor end shall be affixed to the pipe which carries the process stream to be measured. Superinsulation shall cover all sensors at low temperature.

c. Sensor loop accuracy, sensitivity, repeatability, and stability shall meet or exceed the following specifications:

Temp. range [K]	Accuracy [mK]	Sensitivity [mK]	Repeatability [mK]	Stability [mK/year]
2–6	± 150	2	± 2	± 10
6–40	± 300	6	± 6	± 30
40–100	± 550	10	± 10	± 50

3.6.3 Units

The units given below are preferred for all instrumentation readouts supplied with the system, any deviations require URA approval. English equivalents mentioned in the text are for clarification only and should not be used in instrumentation readouts.

a. All pressures shall be given in bar absolute unless noted otherwise.

b. Vacuum readings shall be given in millibar (mbar) absolute.

c. Temperatures shall be given in either K or °C as noted. In general, it is preferred that temperatures be expressed as Kelvin for the range below ambient, and in degrees Celsius for the range above ambient. For the purposes of this RFI, the ambient temperature T0 is assumed to be 305 K.

d. Flow rates shall be given in grams per second (g/s).

e. Time shall be given in seconds or hours as noted.

f. Standard S.I. units (see Standard ISO 1000) shall be used for all other quantities.

3.7 Environment, Safety, and Health

The DOE and URA are committed to the policy of ensuring that all activites associated with the construction and operation of the SSCL shall be in compliance with the applicable federal and other environment, safety, and health regulations.

3.7.1 Hazardous chemicals

The subcontractor will be responsible for the safe use, storage, and disposal, in accordance with all applicable laws, of any chemnical or other material used in performance of the work. The subcontractor shall provide a list of all hazardous materials, as listed by OSHA and/or EPA, used in performance of the work and shall provide a copy of the Material Safety Data Sheet (MSDS) for each hazardous material listed.

The subcontractor shall require of all lower-tier subcontractors, employees, agents, and all other persons performing work the same responsibility for the aforesaid safe use, storage, and disposal of such materials. The subcontractor shall require its lower-tier subcontractors, materialmen, agents, employees, and other persons performing work to use a substitute for any specified hazardous material whenever so directed by URA. All hazardous material brought onto the SSCL premises shall bear a label stating the identity of the material, any hazards associated with it, and the name of the party responsible for bringing such material onto the site.

Any waste in any form which results from the work must be properly disposed of by the subcontractor in a safe manner, protective of the environment and in accordance with all applicable laws. The subcontractor shall be considered the generator and owner of any hazardous substances, pollutants, or contaminants it may bring onto the work site or that may be generated as a result of its performance of thework.

4.0 Quality Issues

4.1 Reliability

The mean time between failures (MTBF) for each CCB shall be at least 6,000 hours.

For purposes of this calculation, any reduction of the CCB performance below minimum mode requirement given in Section 3.??? shall be termed a failure and shall count in the assessment of MTBF.

4.2 Mean Down Time

The mean down time (MDT) for the CCB shall be no greater than six (6) hours. For the purposes of this calculation, MDT is measured from the point at which CCB performance falls below minimum mode requirement given in Section 3.?? and the point when that performance is restored.

4.2 Availability

CCB availability shall be calculated as:

$$\text{Availability} = \frac{\text{Scheduled Uptime} - \text{Unscheduled Downtime}}{\text{Scheduled Uptime}}$$

The minimum availability of each CCB shall be at least 0.99875.

The contractor is encouraged to discuss operating strategies which will improve the availability of the CCB.

4.4 Maintainability

The CCB shall be designed for ease of fault diagnosis and correction. Items liable to failure shall be readily accessible so that URA technician personnel can easily, safely, and reliably carry out any necessary inspection, maintenance or repair.

Documentation

Submittals

a. For each submittal, three (3) copies of all engineering documentation shall be submitted as follows: (Specific guidelines shall be given in following sections.)

Two (2) paper copies

One (1) electronic copy on 3.5" floppy diskette formatted for Macintosh or PC-DOS.

b. The numbering system for all engineering documents shall be in accordance with this technical specification, Appendix D.

URA Engineering Approvals

All contractor engineering documentation shall be sent to the SSCL for approval by URA and thirty (30) days shall be allowed for that approval.

Text Document Formats

a. Text documents are documents other than drawings and databases (e.g., specifications, operating and maintenance manuals) which are part of the engineering function.

b. Text documents shall be electronically created and maintained using either of the following software packages:

1. Microsoft Word for Macintosh, v5.0 unless a later version is authorized by URA.
2. Microsoft Word for Windows (IBM PC compatible), v2.0 unless a later version is authorized by URA.

c. Operating and maintenance manuals delivered with standard, off-the-shelf equipment procured by the contractor is not required to be delivered in electronic format unless readily available.

Drawing Formats

a. All drawings delivered to the SSCL shall be CAD drawings.

b. Manual and/or electronically scanned drawings are not acceptable.

c. All drawings shall be submitted as follows:

1. Paper: one (1) vellum and one (1) blue-line or equal
2. Electronic: either of the following formats:

    Intergraph/MicroStation (preferred) PC 4.0 or later

    AutoCAD v10 or later

d. If CAD files are translated from electronic format different from AutoCAD or MicroStation, the contractor shall examine the translated CAD file using either AutoCAD or MicroStation to assure accuracy and completeness of the translation. This shall be accomplished prior to sending the translated files to the SSCL.

e. Drawings reduced from their original size are not acceptable, unless specifically requested by URA.

f. The maximum size drawing submitted shall be E-size (44" x 34").

g. Drawings on architectural size paper shall not be allowed.

h. All revisions of a drawing shall be indicated on the drawing by clouding and shall specifically be noted in the revision block of that drawing.

i. General revisions to drawings shall not be allowed.

j. As-built drawings shall be submitted in full size and shall be printed on mylar.

k. Parts lists/bills of material shall be prepared integrally with any drawings where it is required and shall be shown on the first sheet of those drawings.

l. The contractor shall use either the S.I. or English system for design documentation and drawings. The system selected by the contractor shall remain consistent throughout the proposal and for all work, with the measurement given in parentheses in the alternate system of notation for all primary measurements.

Document Numbering

All CCB documents shall be numbered A H A - XXXXX, where XXXXX is a unique document number in the sequence 60000 to 60999.

The contractor shall subdivide the sequence 60000 to 60999 in some logical order to localize document significance.

Design Basis Document

The design basis document shall include the following information:

6 Notes

6.1 Instrument Air

Dew Point

Pressure

Flow/pressure Limitations
Particulate size

6.2 Electrical

Phase, Frequency,Voltage, Current limitation

6.3 Liquid Nitrogen

Supply Pressure, discharge pressure, volume (g/s)

6.4 Limiting Weights and Dimensions

Maximum dia
Max height
Vacuum enclosure
Projections
CCB bayonet interface
Max weight TBD kg (TBD lbs)
Floor loading TBD kg/cm2 (TBD psi)
Transfer line interface projection
To shaft
To distribution box

6.5 Installation

Shaft access (see fig ??)
Shaft has a clear drop zone dia TBD m (TBD ft).
Hoist installed? lift capacity TBD tonnes (TBD tons).
Floor load capacity at shaft head TBD kg/cm2 (TBD psi)
Floor load capacity in Adit TBD kg/cm2 (TBD psi)

6.6 Environmental Conditions

a) Relative Humidity 80%
b) Temperature 80°F (27°C).
c) Structural Vibration:

It is predicted that structural vibrations in the machinery areas will be minimal. All local machinery will be rotating (vacuum pumps, circulating pumps), less than 10 kW power input and effectively vibration isolated from the structure.

6.7 Equipment Layout

6.8 Definitions

T1 inlet temperature, K.
P1 static inlet pressure, bar
m mass flow, g/s
_H change in Enthalpy, j/g
_P change in static pressure, mbar

STATEMENT OF WORK (SOW)

FOR THE

COLD COMPRESSOR BOX

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

11 FEBRUARY 1993

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Cold Compressor Box Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.2 Start of Work Meeting 4
3.1.2.3 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 6
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.5 Reserved 7
3.2 Fabrication 8
3.2.1 Reserved 8
3.2.2 Reserved 8
3.2.3 Schedule 8
3.2.4 Shop Witness Points 8
3.2.5 Material Control 8
3.2.6 Processes and Methods 8
3.2.7 Testing 9
3.2.8 Spares 9
3.2.9 Reserved 9
3.3.10 Installation 10
3.3 Logistics 10
3.3.1 Operating Manuals 10
3.3.2 Training 10
3.3.3 Special Tools and Equipment 11
3.3.4 Maintenance Manual 11

3.4 Reserved 11
3.5 Program Management 11
3.5.1 Contractor Work Breakdown Structure (CWBS) 12
3.5.2 Lower Tier Subcontract Management 12
3.5.3 Program Schedule 12
3.5.4 Configuration Management (CM) and Control 12
3.5.5 System Safety 12
3.5.5.1 Safety Analysis 12
3.5.5.2 Material Safety Data Sheets (MSDS) 13
3.5.5.3 On-Site Activities 13
3.6 Quality Assurance 14
3.7 SSCL Numbering System 14
3.8 Units of Measure 14
3.9 Reserved 14
3.10 Management Reviews and Technical Meetings 14
3.10.1 Technical Interchange Meetings (TIM) 14
3.10.2 Technical Reviews 14
3.11 Technical Reports 15
3.12 Cost/Schedule Reports 15
3.13 Interface Control Documents (ICD) 15
4.0 Reserved 16
5.0 Contractor Furnished Property/Services 17
5.1 Contractor Furnished Property 17
5.2 Contractor Furnished Services 17

1.0 SCOPE

This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, install 12 Cold Compressor Boxes (CCB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements are contained in AHW-XXXXX.XXX, the Technical Specification for the CCB.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector. The CCB provides underground conditioning of the cryogen streams outside of the superconducting magnet strings in the sector. The CCB will be located in the cryogenic alcove underground.

The SSCL desires to obtain twelve CCB systems. The CCB procurement of the cryogenic systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

SSCL requires a total of twelve (12) Cold Compressor Box Systems; ten (10) for the collider main ring, and two (2) for the high energy booster (HEB). This SOW sets forth the contract requirements for the Cold Compressor Systems.

1.2 *OBJECTIVE*

The objective of this procurement is to deliver Cold Compressor Box Systems with accompanying data, spare parts, and training on the schedule required to support collider installation.

The overall objective is for the subcontractor to deliver Cold Compressor Box Systems that meet all the performance requirements while providing ease of operation and maintainability for URA over the system life.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the CCB design requirements baseline in the form of a product fabrication specification.

b. *Present the design calculations, product specifications, process specifications, drawings and* acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Installation and acceptance testing at SSCL.

d. Maintenance and support of the first CCB during acceptance testing at SSCL.

e. Training.

f. Fabrication and delivery of the CCB production units.

g. Installation of the first production CCB in an underground tunnel.

Detailed requirements for these tasks are given in Section 3.0 below.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists

b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Technical Specification for the Cold Compressor Box System (CCB)

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. CCB Quality Assurance Plan (to be submitted with proposal)

c. CCB Program Management Plan (to be submitted with proposal)

d. CCB Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Technical Specification for the Cold Compressor Box System.

3.1 COLD COMPRESSOR BOX DESIGN

The subcontractor shall design Cold Compressor Box systems in accordance with the requirements of the Technical Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Section 3.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the CCB. The equipment design shall be fully documented in accordance with the Technical Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Technical Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the.item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted no later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.2 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the Cold Compressor Box system no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. the Specification

b. the Statement of Work

c. the Contract Data Requirements List

d. the Schedule

e. Interfaces

f. Quality control planning.

g. Design standardization and logistics

h. the Program Management Plan

i. the Quality Assurance Plan

j. the Configuration Management Plan

k. Program risk assessment

l. Problems and concerns

m. Test Planning

n. SSC Test Support

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 3 - Specifications)
(CDRL No. 5 - Drawings)

3.1.2.3 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the Cold Compressor Box system no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the CCB design has been completed. As a minimum, the following items shall be addressed:

a. Electrical design

b. Mechanical design

c. Interfaces

d. Drawings (Level 2)

e. Specifications

f. Configuration Management

g. Acceptance Test Planning

h. Test Support Planning

i. System safety

j. Fabrication planning

k. Quality Assurance planning

l. Installation planning

m. Failure modes analysis (FMA)

n. Logistics

    1. Transportation, packaging, and handling

2. Standardization
3. Special tools and equipment requirements
4. Spares requirements

o. Program and near term schedules.

p. Program risk assessments

q. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11– Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the Cold Compressor Systems and replacement modules shall be consistent with the Technical Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on Cold Compressor System performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post–replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 – Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL-STD-490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Technical Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11- Critical Item Fabrication Product Specification (C2b))
(CDRL No. 15-Process Specifications)
(CDRL No. XX - Material Specifications)

3.1.4.2 Drawings

The subcontractor shall convert design requirements to practical design layouts (Level 1) and then convert design layouts to detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 - Drawings)

3.1.5 RESERVED

3.2 FABRICATION

The subcontractor shall fabricate, assemble, test, package, and ship all components of the CCB, including those fabricated by its subcontractors, in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the CCB Technical Specification and this Statement of Work, in the quantities and to the schedules shown in Section F of the Subcontract. Fabrication requirements delineated in this section shall also apply to any tasks executed in the field as well as those performed in subcontractor facilities.

3.2.1 Reserved

3.2.2 Reserved

3.2.3 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.4 Shop Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests of all mechanical and electrical, and all instruments and sensors.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.2.5 Material Control

The subcontractor shall implement material control procedures in accordance with its CCB quality assurance program and the Technical Specification. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 – Parts Qualification Plan)

3.2.6 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the Technical Specification. Such processes include, but are not limited to, welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 – Process Specifications)

3.2.7 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the CCB components including all field assembly tasks. Tests required by the Technical Specification and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.3, above, or Section 3.3.4, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 – Fabrication Acceptance Test Plan)

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in the FTR which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.2.8 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.2.9 Reserved

3.3.10 Installation

Each complete CCB shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the Technical Specification and in this Statement of Work. This SOW considers installation tasks to be fabrication tasks accomplished in the field; as such, the requirements of Section 3.2 apply.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and inspection of wiring.

3.3 Logistics

3.3.1 Operating Manuals

The subcontractor shall develop an operating manual which fully describes the operation of the CCB in all modes. The operating manual will use indented danger, warning, caution, and note notations to set off and call attention to the severity of potential consequences of human error or mistake. DANGER notation shall be used for situations where death could occur; WARNING shall be used when severe injury or occupational illness could occur; CAUTION notation shall be used for calling attention to a possible less severe consequence of minor injury or minor occupational illness; and NOTE shall be used to explain critical steps where human assembly errors could cause a failure; in addition, NOTE shall be used to set off and call attention to technical information important to the presentation or action being described, thus NOTE is used as a technical notation.

(CDRL No. 35– Operating Manual)

3.3.2 Training

The subcontractor shall conduct a training course for cryogenic engineers and technicians at a location designated by URA. The course shall consist of both classroom and hands–on training. Training shall be completed prior to installation of the first production CCB.

Sufficient information shall be presented to allow operations personnel to perform safe and efficient startup, operation, and shutdown of the CCB. All manual and computer-automated actions required to operate the system shall be described in detail. Training shall include steady state conditions where the process is under control and steps to take when the CCB reaches out of tolerance performance along with emergency steps required to shut down the process.

Maintenance procedures shall be presented including detailed instructions for the maintenance activities that operations personnel may be required to perform and descriptions of all necessary tools and replacement parts. The frequency of scheduled maintenance shall be reviewed. Complete methods used by operations personnel to diagnose equipment failures shall be covered.

At its discretion, URA may choose to record the training on audio and/or video medium for future use.

A training syllabus shall be provided.

(CDRL No. 40– Training Syllabus)

3.3.3 Special Tools and Equipment

Prior to the installation of the first production CCB (CDRL), The subcontractor shall supply one set of all special tools and equipment required for maintenance.

3.3.4 Maintenance Manual

Prior to installation of the first production CCB (CRDL), A maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure.

(CDRL No. 41– Maintenance Manual)

3.4 Reserved

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, logistics, and installation tasks defined by this SOW in accordance with the CCB program management plan referenced in Section 2.3, above. Note that the management tasks of Section 3.5 pertaining solely to design revision, fabrication, and installation shall only be accomplished after the exercise of contract option 1. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the CCB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contractor Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. XX - CWBS)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedule

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28– Safety Analysis)

3.5.5.2 *Material Safety Data Sheets (MSDS)*

The subcontractor shall prepare and deliver *all* current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.2.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the CCB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA a minimum of ten (10) working days prior to the formal review. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Design reviews (CDR) shall be held at the subcontractor's facilities on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.11 Technical Reports

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 Cost/Schedule Reports

The subcontractor shall provide monthly cost/schedule status reports to URA. The cost/schedule information shall evaluate cost performance against contractual deliverables and schedule.
(CDRL No. 31– Cost/Schedule Reports)

3.13 Interface Control Documents (ICD)

The subcontractor shall support URA in producing the appropriate interface control document(s).
(CDRL No. 32– Interface Control Documents)

4.0 Reserved

5.0 Customer Furnished Property/Services

5.1 Customer Furnished Property

The SSCL Cryogenics Test Bed (?) will be made available to support Acceptance Testing of the CCB. The (?) will be located in the Cryogenics Building at the N15 Site at SSCL. The (?) will provide the same interfaces as the underground cryogenic alcove. The CCB interfaces will be TBD. Available power is TBD VAC, TBD Amps, TBD phases, TBD Hz, and TBD VDC, TBD Amps. See Figure TBD for a description of the Cryogenics Test Bed (?).

5.2 Customer Furnished Services

SSCL will provide the contractor with phone, space for tool storage, instrument calibration lab service, welding shop support, vacuum systems, etc. SSCL will provide power to the CCB electrical panel. SSCL will make the cryogenic connection to the CCB. SSCL will unpack the CCB and emplace the CCB on the Cryogenic Test Bed. The Cryogenic Test Bed will provide the following services:

Compressed Air: TBD SCFM at TBD psig

80K Nitrogen: TBD SCFM at TBD psig

Water: TBD gpm at TBD psig

???

STATEMENT OF WORK (SOW)

FOR THE

COLD COMPRESSOR BOX
FABRICATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Production Readiness Review (PRR) 3
3.3 Fabrication 4
3.3.1 Schedule 4
3.3.2 Shop Witness Points 4
3.3.3 Material Control 5
3.3.4 Processes and Methods 5
3.3.5 Testing 5
3.3.6 Spares 6
3.3 Reserved 6
3.4 Reserved 6
3.5 Program Management 6
3.5.1 Contract Work Breakdown Structure (CWBS) 6
3.5.2 Lower Tier Subcontract Management 6
3.5.3 Program Schedules 7
3.5.4 Configuration Management (CM) and Control 7
3.5.5 System Safety 7
3.6 Quality Assurance 8
3.7 SSCL Numbering System 8
3.8 Units of Measure 8
3.9 Reserved 9
3.10 Management Reviews and Technical Meetings 9
3.10.1 Technical Interchange Meetings (TIM) 9
3.10.2 Resserved 9
3.11 Technical Reports 9
3.12 Cost Reports 9
4.0 Reserved 10
5.0 Customer Furnished Property/Services 10
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 11

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Cold Compressor Box (CCB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to fabricate eleven (11) Cold Compressor Box (CCB) for the Superconducting Super Collider Laboratory (SSCL). *Technical requirements for the CCB are contained in the Product and* Material Specifications for the Cold Compressor Box, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one CCB located in the cryogenic chamber at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype CCB at N-15 of the SSC. The fabrication of eleven (11) production CCB, two (2) for the HEB and nine (9) for the SSC, is included in this contract.

Procurement of these systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to deliver production CCB, with accompanying data and spare parts, in accrodance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Maintenance of the design baseline established under the basic contract.

b. Conduct of a Production Readiness Review (PRR).

c. Fabrication of eleven (11) production CCB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Cold Compressor Box

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

f. *XXXXXXXXXX*, Product Specification for the Cold Compressor Box.

g. *XXXXXXXXXX*, Material Specification for the Cold Compressor Box.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

d. Subcontractor Configuration Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Cold Compressor Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting of the CCB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Configuration Management

f. Quality Assurance

g. Producibility

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 PRODUCTION READINESS REVIEW (PRR)

The subcontractor shall conduct a PRR no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that any TL system design problems encountered during development have been resolved, and that adequate documentation of technical readiness and anticipated production costs are available for production phase release. As a minimum, the following items shall be addressed:

a. Product design:

   1. Producibility,

   2. Review of design changes during first article build and install,

   3. Design validation for performance, reliability, and maintainability.

b. Plant capacity, skilled personnel, and training resources.

c. Production Engineering and Planning:

   1. Compatability of production schedule with delivery requirements,

2. Integration of manufacturing methods and processes with facilities, equipment, tooling, and layout.

d. Materials and purchased parts:

1. Completeness of bill of materials,

2. Identification of long lead items,

3. Adequacy of inventory control system.

4. Spare part requirements.

e. Quality Assurance.

f. Safety Program.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.3 FABRICATION

The subcontractor shall fabricate all components of eleven (11) production CCB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of the production units will be in accordance with Section F of the subcontract.

3.3.1 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.3.2 Shop Witness Points

The following witness points shall be included in the subcontractor's fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.3.3 Material Control

The subcontractor shall implement material control procedures in accordance with the CCB quality assurance program, CCB system specifications, and the Parts Qualification Plan approved under the basic contract.

3.3.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special fabrication processes required to satisfy the provisions of the CCB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.3.5 Testing

The subcontractor shall conduct a fabrication test program during fabrication and assembly of the CCB components. Tests required by the CCB specifications and the subcontractor's quality assurance program shall be included. The fabrication test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.3.2 and 3.3.4, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.3.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the fabrication tasks defined by this SOW in accordance with the CCB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the CCB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of fabrication and installation processes. The subcontractor shall identify potential risk factors associated with fabrication, installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the CCB specifications.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the CCB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Resserved

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

COLD COMPRESSOR BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1, .2 3.10.1	As Req'd	No
2	Meeting Minutes	3.1, .2 3.10.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.3.5	FT 5D	No
19	Fabrication Test Report	3.3.5	As Req'd	No
20	Spare Parts List	3.3.6	PRR	No
27	Program Schedules	3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	Updates	Yes
29	Material Safety Data Sheets	3.5.5.2	Updates	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No

<u>Delivery Examples</u>- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.3.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.3.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.3.6

CDRL 27 - Program Schedules

Reference SOW paragraph 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

<u>CDRL 29 - Material Safety Data Sheets</u>

Reference SOW paragraph 3.5.5.2

<u>CDRL 30 - Monthly Report</u>

Reference SOW paragraph 3.11

<u>CDRL 31 - Cost Reports</u>

Reference SOW paragraph 3.12

<u>CDRL 35 - Contract Work Breakdown Structure</u>

Reference SOW paragraph 3.5.1.

<u>CDRL 36 - Contractor Organization</u>

Reference SOW paragraph 3.5

<u>CDRL 37 - Lower Tier Subcontract Data</u>

Reference SOW paragraph 3.5.2

STATEMENT OF WORK (SOW)

FOR THE

COLD COMPRESSOR BOX
INSTALLATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Installation 3
3.2.1 Schedule 3
3.2.2 Witness Points 4
3.2.3 Processes and Methods 4
3.2.4 Testing 4
3.3 Program Management 5
3.3.1 Reserved 5
3.3.2 Reserved 5
3.3.3 Program Schedules 5
3.3.4 Reserved 5
3.3.5 System Safety 5
3.3.5.1 Safety Analysis 5
3.3.5.2 Material Safety Data Sheets (MSDS) 5
3.3.5.3 On-Site Activities 6
3.4 Quality Assurance 6
3.5 SSCL Numbering System 7
3.6 Units of Measure 7
3.7 Reserved 7
3.8 Management Reviews and Technical Meetings 7
3.8.1 Technical Interchange Meetings (TIM) 7
3.8.2 Resserved 7
3.9 Technical Reports 7
3.10 Cost Reports 8
4.0 Reserved 8
5.0 Customer Furnished Property/Services 8
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 9

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring the services required to install Cold Compressor Boxes (CCB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to install eleven (11) Cold Compressor Boxes (CCB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the CCB are contained in the Product and Material Specifications for the Cold Compressor Box, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one CCB located in the cryogenic chamber at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype CCB at N-15 of the SSC. The installation of eleven (11) production CCB, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these services is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to perform the installations of production CCB in accordance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Conduct of a Start of Work Meeting

b. Installation of eleven (11) production CCB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. AHW-XXXXX.XXX Development Specification for the Cold Compressor Box

b. Accelerator Systems Division Safety and Health Program Manual

c. SSCL Practice D10-000003, Hazard Analysis Instructions

d. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

e. *XXXXXXXXXX*, Product Specification for the Cold Compressor Box.

f. *XXXXXXXXXX*, Material Specification for the Cold Compressor Box.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Cold Compressor Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting for the installation of the CCB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications and drawings

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Quality Assurance

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 INSTALLATION

The subcontractor shall install all components of eleven (11) production CCB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of installation services will be in accordance with Section F of the subcontract.

3.2.1 Schedule

The subcontractor shall maintain an installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Witness Points

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Functional tests.

b. Final pressure and temperature tests and vacuum leak checking.

3.2.3 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special installation processes required to satisfy the provisions of the CCB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.2.4 Testing

The subcontractor shall conduct a test program during installation and assembly of the CCB components. Tests required by the CCB specifications and the subcontractor's quality assurance program shall be included. The installation test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.2.2 and 3.2.3, above, the results shall be reported to URA within five (5) days of completion of the test.

(**CDRL No. 18** - Witnessed Installation Test Results)

The results of all installation tests, including witnessed tests, shall be compiled by the subcontractor in an Installation Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(**CDRL No. 19** - Installation Test Report)

3.3 PROGRAM MANAGEMENT

The subcontractor shall manage the installation tasks defined by this SOW in accordance with the CCB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the CCB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.3.1 Reserved

3.3.2 Reserved

3.3.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.3.4 Reserved

3.3.5 System Safety

3.3.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of installation processes. The subcontractor shall identify potential risk factors associated with installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the CCB specifications.

(CDRL No. 28– Safety Analysis)

3.3.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29- Material Safety Data Sheets)

3.3.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.4 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.5 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.6 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the CCB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.7 RESERVED

3.8 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.8.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.8.2 Resserved

3.9 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.10 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

COLD COMPRESSOR BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.8.1	As Req'd	No
2	Meeting Minutes	3.1 3.8.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.2.4	FT 5D	No
19	Fabrication Test Report	3.2.4	As Req'd	No
27	Program Schedules	3.2.1 3.3.3	Monthly	No
28	Safety Analysis	3.3.5.1	Updates	Yes
29	Material Safety Data Sheets	3.3.5.2	Updates	Yes
30	Monthly Report	3.9	Monthly	No
31	Cost Reports	3.10	Monthly	No
36	Contractor Organization	3.3	CA 30D	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based changes from Data submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,
b. name(s) of meeting chairperson(s) or person calling the meeting,
c. schedule of items to be discussed and presenters,
b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,
b. discussion of each pertinent agenda item,
c. recommendations provided by both subcontractor and URA,
d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.4

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.4

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.3.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.3.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.9

CDRL 31 - Cost Reports

Reference SOW paragraph 3.10

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.3

STATEMENT OF WORK (SOW)

FOR THE

COLD COMPRESSOR BOX

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Cold Compressor Box Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.1 Start of Work Meeting 4
3.1.2.2 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 6
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.4.3 Interface Control Documents (ICD) 7
3.2 Fabrication and Installation 7
3.2.1 Schedule 7
3.2.2 Shop/Field Witness Points 8
3.2.3 Material Control 8
3.2.4 Processes and Methods 8
3.2.5 Testing 8
3.2.6 Spares 9
3.2.7 Reserved 9
3.2.8 Installation 9
3.2.9 Maintenance Manual 9
3.3 Reserved 10
3.4 Reserved 10
3.5 Program Management 10
3.5.1 Contract Work Breakdown Structure (CWBS) 10
3.5.2 Lower Tier Subcontract Management 10
3.5.3 Program Schedules 11
3.5.4 Configuration Management (CM) and Control 11
3.5.5 System Safety 11

3.5.5.1 Safety Analysis 11
3.5.5.2 Material Safety Data Sheets (MSDS) 11
3.5.5.3 On-Site Activities 12
3.6 Quality Assurance 12
3.7 SSCL Numbering System 12
3.8 Units of Measure 12
3.9 Reserved 13
3.10 Management Reviews and Technical Meetings 13
3.10.1 Technical Interchange Meetings (TIM) 13
3.10.2 Technical Reviews 13
3.11 Technical Reports 13
3.12 Cost Reports 14
4.0 Reserved 14
5.0 Customer Furnished Property/Services 14
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 15

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Cold Compressor Boxes (CCB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, and install one prototype Cold Compressor Box (CCB) at N15 of the Superconducting Super Collider Laboratory (SSCL).

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one CCB located in the cryogenic chamber at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. Technical and functional descriptions of the CCB are contained in AHW-XXXXX.XXX, Development Specification for the Cold Compressor Box.

Procurement of this prototype CCB is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objectives of this procurement are to deliver a production design with accompanying data and program management services, fabricate a prototype CCB, and install the prototype at site N-15 to support collider cooldown testing.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the CCB design requirements baseline in the form of a product fabrication specification and drawing package.

b. Present the design trade-offs, product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Fabricate the prototype CCB.

d. Installation and acceptance testing at the N-15 site of the SSC.

e. Maintenance and support of the prototype CCB during cool down testing at SSC.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW-XXXXX.XXX Development Specification for the Cold Compressor Box

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan (to be submitted with proposal)

c. Subcontractor Program Management Plan (to be submitted with proposal)

d. Subcontractor Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Development Specification for the Cold Compressor Box.

3.1 COLD COMPRESSOR BOX DESIGN

The subcontractor shall design the CCB in accordance with the requirements of the Development Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Sections 3, 4 and 5.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the CCB. The equipment design shall be fully documented in accordance with the Development Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Development Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted not later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.1 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the CCB not later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Development Specification

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Interfaces

f. Design standardization and maintenance

g. Program Management Plan

h. Quality Assurance Plan

i. Configuration Management Plan

j. Program risk assessment

k. Problems and concerns

l. Test Planning

m. SSC Test Support

n. Installation planning

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.1.2.2 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the CCB not later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the CCB design has been completed. As a minimum, the following items shall be addressed:

a. Design

b. Interfaces

c. Drawings, Level 2

d. Specifications

e. Configuration Management

f. Acceptance Test Planning

g. Test Support Planning

h. System safety

i. Fabrication planning

j. Quality Assurance planning

k. Installation planning

l. Failure modes analysis (FMA)

m. Logistics

   1. Transportation, packaging, and handling
   2. Standardization
   3. Special tools and equipment requirements
   4. Spares requirements

n. Program and near term schedules.

o. Program risk assessments

p. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings, Level 2)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11- Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the CCB and replacement modules shall be consistent with the Development Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on CCB performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post-replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 – Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL-STD-490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Development Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11-Product Specification (C2b))

(CDRL No. 15-Process Specifications)

(CDRL No. 21 - Material Specifications)

3.1.4.2 Drawings

The subcontractor shall convert design requirements into practical design layouts (Level 1) and then convert design layouts into detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 -As Built Drawings)

3.1.4.3 Interface Control Documents (ICD)

The subcontractor shall support URA in producing the appropriate interface control document(s).

(CDRL No. 32- Interface Control Documents)

3.2 FABRICATION AND INSTALLATION

The subcontractor shall fabricate and install all components of the prototype CCB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work.

3.2.1 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Shop/Field Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop/Field functional tests.

b. Final shop/field pressure and temperature tests and vacuum leak checking.

3.2.3 Material Control

The subcontractor shall implement material control procedures in accordance with the CCB quality assurance program and CCB specifications. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 - Parts Qualification Plan)

3.2.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the CCB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 - Process Specifications)

3.2.5 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the CCB components including all field assembly tasks. Tests required by the CCB specifications and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria,

b. Identification of equipment and supplies required,

c. Detailed test procedure,

d. Form(s) for reporting the test results.

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.4, above, or Section 3.2.10, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 - Fabrication Test Plan)

(CDRL No. 18 - Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 - Fabrication Test Report)

3.2.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 - Spare Parts List)

3.2.7 Reserved

3.2.8 Installation

The prototype CCB shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the CCB specifications and in this Statement of Work. This SOW considers installation tasks to include fabrication tasks accomplished in the field.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and leak checks.

3.2.9 Maintenance Manual

Prior to installation of the prototype CCB, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure. The manual shall include a list of all spares and equipment required for maintenance.

(CDRL No. 41- Maintenance Manual)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, and installation tasks defined by this SOW in accordance with the CCB Program Management Plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the CCB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36- Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37- Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27- Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28- Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the CCB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) The system selected by the subcontractor shall remain consistent throughout the proposal and for all work, with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA in accordance with Section F of the subcontract. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Reviews shall be held at the subcontractor's facility on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30- Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31- Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

TBD

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

COLD COMPRESSOR BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2 3.10.1,.2	As Req'd	No
2	Meeting Minutes	3.1.2.1,.2, 3.10.1,.2	As Req'd	Yes
5	Drawings, Level 2	3.1.2.2	30D CDR	Yes
7	Reliability Analysis	3.1.2.2 3.1.3.1	CDR	Yes
8	Failure Modes Analysis	3.1.2.2 3.1.3.2	CDR	Yes
10	Maintainability Program Plan	3.1.2.2	CDR	Yes
11	Product Specifications	3.1.2.2 3.1.4.1	30D CDR	Yes
12	As Built Drawings	3.1.4.2	As Req'd	Yes
14	Parts Qualification Plan	3.2.3	60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.4	CDR 60D	Yes
17	Fabrication Test Plan	3.2.5	As Req'd	Yes
18	Witnessed Fabrication Test Results	3.2.5	FT 5D	No
19	Fabrication Test Report	3.2.5	As Req'd	No
20	Spare Parts List	3.2.6	60D Install	No
21	Material Specifications	3.1.4.1	CDR 60D	Yes
23	Acceptance Test Plan	3.1.2.2	CDR	Yes

27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.1.4.3	As Req'd	Yes
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
41	Maintenance Manual	3.2.9	120D Install	Yes

Delivery Examples- *CA 30D = 30 days after Contract Award, 30D CDR = 30 days before CDR*

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 5 - Drawings, Level 2

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,

b. probability of occurrence of each failure mode,

c. times during operation the failure mode can occur,

d. classification of the failure mode (critical, major, minor),

e. end item reliability when the failure occurs,

f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

CDRL 11 - Product Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 12 - As Built Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 14 - Parts Qualification Plan

The plan shall contain, but is not limited to ,the following

a. the inspections and tests necessary to qualify the part,
b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,
c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,
d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,
e. and the data to be recorded.

CDRL 15 - Process Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 17 - Fabrication Test Plan

Reference SOW paragraph 3.2.5

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 21 - Material Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program using a block diagram portrayal of the functions that must be met to satisfy the total acceptance program,
2. Milestones. Identifies the start and expected completion dates of each test to be performed,
3. Participation. Identifies the contractor and URA participation roles and responsibilities,
4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,
2. Number for each piece of equipment or item test will be performed,
3. Name and brief description of test to be performed,
4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;
2. All support equipment by description, nomenclature and serial number;

3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative

terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,

b. Time allocated for each topic of instruction,

c. Scheduled order of presentation,

d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

04/06/94 10:14 AM

Revision: 0

DRAFT 2

TECHNICAL SPECIFICATION

of the

Tunnel Distribution Box (TDB)

part of the

Sector Tunnel System (STS)

for the

Collider Main Ring

[High Energy Booster (HEB) Ring]

submitted by the

Superconducting Super Collider Laboratory (SSCL)

Accelerator Systems Division / Cryogenics Systems Department

Prepared by:

____

Donald S. Finan

ASD / Cryogenics

Approved By:

____

ASD/ Cryogenics

Table of Contents

Tunnel Distribution Box (TDB)

1.0 Scope

This specification, in conjunction with associated drawings and other applicable documents, details the technical requirements of the design, configuration, fabrication, materials, quality assurance, inspection, testing, cleaning, and packaging for the Tunnel Distribution Box (TDB) for the Superconducting Super Collider Laboratory, operated by the Universities Research Association (URA).

The TDB is a helium cryostat system that is an intregal part of the Collider [high energy booster (HEB)] underground cryogenic equipment will be installed in the tunnel adit area.

1.1 Intended Use

The TDB will be used to convey and control helium and nitrogen flows within the Collider [HEB] dipole magnets string located within each tunnel sector.

1.2 Associated Equipment

The TDB is to interface with the Adit Transfer Line (ATL), the Nitrogen Distribution Box (NDB) and the four [two] SPRF Feed Spools.

2.0 Applicable Documents

The following documents of the exact issue shown form a part of this specification document to the extent specified herein. If a conflict arises between the documents referenced below and the contents of this specification, the latter shall prevail.

2.1 Industry and Society Documents

American Society of Mechanical Engineers (ASME)

B31.3: Chemical Plant and Petroleum Refinery Piping

American Society for Testing and Materials (ASTM)

a. A 312: Stainless Steel Pipe

b. A 269 Stainless Steel Tubing

c. A 380-88: Standard Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems

d. E 493-73(80), E 498-73(80), E 499-73(80): Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector ..(various modes)

Compressed Gas Association (CGA)

a. CGA P-12: Safe Handling of Cryogenic Liquids

b. CGA P-14: Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres

c. CGA S-1.3: Pressure Relief Device Standards—Part 3: Compressed Gas Storage Containers

d. CGA 341: Insulated Cargo Tank for Cryogenic Liquids

National Institute of Standards and Technology (NIST)-(formerly [NBS])

NIST Technical Note 1334: Thermophysical Properties of Helium-4 from 0.8 to 1500 K with Pressures to 2000 MPa

2.2 SSCL Documents

The following are required documents for use in the design of the Tunnel Distribution Box (TDB)

SSCL Dwg. Number	Title
AHA xxxxx	Sector Distribution System, P&ID
AHA 07001	Tunnel Distribution Box Shell
AHA 620xx	Tunnel Distribution Box, "xxx" Lines
(tbd)	*(tbd)*

The following documents provide additional information and background but are not part of the requirements of this specification:

1. ``SSC Cryogenics System,'' *Site-Specific Conceptual Design* (SSC-SR-1056). Dallas, Texas: SSC Laboratory, July, 1990.

2. Than, R., S. Abramovich and V. Ganni. ``The SSCL Cryogenic System Design and the Operating Modes,'' SSCL Cryo Note 92-12, October 1992.

2.3 Source of Documents

Any difficulty in obtaining the applicable documents should be referred to the SSCL Subcontract Administrator. Documents may be obtained from the following:

2.3.1 Industry and Society Documents

Copies can be obtained from the appropriate professional organization referenced. Reference copies of technical society and association documents are generally available in libraries.

2.3.2 SSCL Documents

Frank Rydeen
Deputy Chief Engineer
2550 Beckleymeade Avenue
Dallas, TX 75237

3.0 Requirements

3.0.1 System Configuration

a. SSCL drawing *(tbd)* specifies the required configuration: i.e., size of the vacuum vessel, location and dimensions of required design penetrations, support details and orientation of piping at the interfaces.

b. The routing of piping inside the vessel is conceptual, and must be designed in detail by the Subcontractor as specified in *(tbd)* and conforming to the respective P&ID drawing.

c. The six (6) interface connection ports dimensions must be held to tolerances as shown on the *(tbd)* drawing.

d. Any deviations from this configuration must be shown as an exception to this specification.

e. Valving will be specified by SSCL within the requirements Appendix *(tbd)* .

3.0.2 Descriptions

The Tunnel Distribution Box (TDB) is a distribution cryostat that is installed within the tunnel area of the Collider [high energy booster (HEB)] and will be used to convey helium and nitrogen within the tunnels. It is installed between the Adit Transfer Line (ATL), the Nitrogen Distribution Box (NDB) and the four [two] SPRF feed spools. It consists of a series of piping circuits each with distribution headers and control valves. These circuits control the flow of cryogens to and from the Collider [HEB] rings.

The Collider {HEB} will contain one TDB per refrigeration Sector which gives a total of ten per the Collider (two for the HEB).

Refer to Appendix *(tbd)* for flow diagram and isometric drawings for details of a N25 site model Tunnel Distribution Box (TDB) for the Collider.

The following descriptions are based on the N25 Collider model:

3.0.2.1 4K He Supply Circuit (4KHeSply)

The 4K He Supply Circuit receives 4K helium from the ATL and distributes this cryogen to the four [two] magnet strings. The flow from the ATL starts with a 3"NPT line, manifolds to four [two] 1 1/2"NPT flow meter elements. From each flow meter, a 1 1/2 NPT" line connects to a control valve and then exits to the Feed Spool Piece (SPRF) interface.

3.0.2.2 4K He Return Circuit (4KHeRtn)

The 4K He Return Circuit receives 4K plus helium from the four

[two] magnet strings and returns this cryogen to the ATL. The interface from each SPRF starts with a 1 1/2" NPT line and connects to an isolation valve. Each valve outlet connects to a 3" NPT manifold which exits to the ATL interface.

3.0.2.3 20K Supply Circuit (20KHeSply)

The 20K Supply Circuit receives gas helium(GHe) from the ATL and distributes this cryogen to two (a single) magnet strings. The flow starts with a 4"NPT line, manifolds to two [a] 3"NPT flow meter elements. From each flow meter, a 3"NPT line connects to a control valve and then exits to a SPRF interface.

3.0.2.4 20K Return Circuit (20KHeRtn)

The 20K Return Circuit receives GHe from two { a single} magnet strings and returns this cryogen to the ATL. The interface from each SPRF starts with a 3"NPT line and connects to an isolation valve. Each valve outlet connects to a 4"NPT manifold which exits to the ATL interface.

3.0.2.5 Gas Helium Return Circuit (GHeRtn)

The Gas Helium Return Circuit receives GHe from four (two) magnet strings and returns this cryogen to the ATL. The interface from each SPRF starts with a 3"NPT line and connects to an isolation valve. Each valve outlet connects to a 4"NPT manifold which exits to the ATL interface.

3.0.2.6 80K Liquid Nitrogen Supply (80KLN2)

The 80K Liquid Nitrogen Supply System consists of five {three} separate piping circuits within the TDB. The circuit #1 receives liquid nitrogen from the ATL and distributes this cryogen to the TDB shield and the Nitrogen Distribution Box (NDB). This flow starts with a 3"NPT line and branches to the TDB shield piping system. The main 3"NPT run continues through the TDB to the NDB interface. Circuits #2,3,4,5 {#2,3} are separate distribution runs from the NDB directly to each SPRF interface.

3.0.2.7 80K Gas Nitrogen Return (80KGN2)

The Gas Nitrogen Return Circuit receives GN2 from four (two) magnet strings and GN2 from the NDB and returns these cryogen flows to the ATL. The interface from each SPRF starts with a 2 1/2"NPT line and connects to an isolation valve. The outlet from each valve and the line from the NDB connect to a 4"NPT manifold which exits to the ATL interface.

3.0.2.8 Vacuum Vessel and Thermal Shield

The vacuum vessel is a horizontal cylinder with full diameter access ports (removable heads) on each end. These large ports are to be used for the initial assembly of the internal piping and thermal shield. These access ports and others on the cylinder surface will also be used for maintenance operations and instrument servicing, in particular the ventui flowmeters. An internal thermal shield is cooled by a 80K nitrogen side-stream supplied by a small LN2 vessel mounted above the shield within the main vacuum vessel shell. This entire vessel, with protruding interface connection ports, is inserted into the SSC Collider [HEB] tunnel adit which has limited room for maneuverability and service access. The connection ports are to be designed for ease of assembly at the ATL, NDB, and SPRF's interconnect points. The surfaces of these components, consisting of inner process piping, shield material and outer vacuum shell, must be precisely located for a proper fit to each mating part.

3.1 Process Piping Requirements

Compensation for the thermal expansion and contraction of the inner pipe relative to the vacuum vessel shall be by a method which results in an allowable stress in the piping, vacuum vessel and other components The Subcontractor shall design the pipe sections between valves and other components to prevent excessive lateral loading on the valves. All valves must be able to operate freely under any combination of design loadings.

The Subcontractor, as part of his design function, shall perform stress analysis of the piping (and other equipment) and supports. The results of the stress analysis and drawings of pipe supports, anchors and piping layout drawings shall be submitted to the SSCL for review and approval before fabrication of the piping system. Examples of piping analysis that include contraction of piping due to thermal differences are shown in Appendix *(tbd)* .

The Subcontractor shall provide supports, as necessary, for all piping and valves, provided under this specification.

All low temperature piping circuits shall be equipped with provision for relief valves for each volume that can be isolated. Relief valves shall be sized and provided by the Subcontractor.

The process piping and shield piping shall be constructed of austenitic stainless steel AISI 304L or 304 as specified in below. Seller shall identify all materials of construction in proposal.

The SSCL requires that long radius elbows (R/D = 1.5) be used wherever possible in order to reduce the pressure drop.

The following coefficients shall be used for the pressure drop calculations except where Seller believes that values should be used which result in a higher pressure drop.

Item	Velocity Heads
Standard Elbow (r = d)	0.90
Long Sweep Elbow (r=1-1/2" d)	0.60
45° Elbow	0.42
Tee (branch flow)	1.8

3.1.1 General specifications and references :

a. P&ID drawing *(tbd)* , shall be used to develop detailed piping design drawings.

b. All piping shall be designed, fabricated, inspected, installed and tested per ASME Standard B31.3, "Chemical Plant and Petroleum Refinery Piping". The requirement for impact tests at design temperature on the thin wall piping (thickness < .099") will be waived.

c. Process piping shall conform to ASTM A312 "Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes" and material shall be type 304 or 304L stainless steel. Instrument tubing shall conform to ASTM A 269 "Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service"

d. All piping shall be cleaned per ASTM..A 380-88.

e. All piping shall be designed for a maximum allowable working pressure (MAWP) of 300 psi (20 bar) minimum at a temperature of 4K .

f. Minimum process pipe wall thickness shall be Schedule 5S.

g. The design of piping supports shall be per current industry standards and shall be based on a flexibility analysis as required by ANSI B31.3 and the worst case operating conditions as listed in Table 1 for each piping system. Expansion joints are not allowed. Allowance for contraction shall be provided through the configuration of the piping runs including piping loops if required.

h. All joints shall be welded and leak checked with a helium MSLD for a maximum leak rate of 10^-9 mbar liter/sec per ASTM #.E 493, 498, 499.

i. The completed piping system shall be leak checked per ASTM #.493, 498, 499.

3.1.2 Piping System Parameters

The design of the piping system shall be based on the following nominal values:

Table 1:

Process Piping System	4KHeSply	4KHeRtn	20K HeSply	20K HeRtn
Fluid Service	supercritical helium at 4K	supercritical helium at 4K	gas helium at 20K	gas helium at 20K
Process Points per Dwg *(tbd)*	from ATL to SPRF	from SPRF to ATL	from ATL to SPRF	from SPRF to ATL
Approx. Length, Ft.	*(tbd)*	*(tbd)*	*(tbd)*	*(tbd)*
Max. Allowable Pressure Drop, mPa (including valve loss)	*(tbd)*	*(tbd)*	*(tbd)*	*(tbd)*
Design Flow **per Branch**, g/s	100	25	100	100
Steady State Operating Pressure , bar	4.0	3.5	3	2
Steady State Operating Temp., K, minimum	4	4	14-18	28

Table 1 (cont)

Process Piping System	GHeRtn	80KLN2	80KLN2	80KGN2
Fluid Service	gas helium 4K	liquid nitrogen supply at 80K	liquid nitrogen supply at 80K	gas nitrogen return at 80K
Process Points per Dwg *(tbd)*	from SPRF to ATL	from ATL to NDB	from NDB to SPRF	from SPRF to ATL
Approx. Length, Ft.	*(tbd)*	*(tbd)*	*(tbd)*	*(tbd)*
Max. Allowable Pressure Drop, mPa (including valve loss)	*(tbd)*	*(tbd)*	*(tbd)*	*(tbd)*
Design Flow **per Branch,** g/s,	68	4800	1200	1200
Steady State Operating Pressure , bar	.77	3-10	3-10	1.5
Steady State Operating Temp., K, minimum	3.95	80-85	80-85	85

3.2 Vacuum Vessel Requirements

3.2.1 Dimensions

The vessel and interface connection dimensions shall conform to Drawing *(tbd)*

3.2.2 Material and Pressure Rating

The vacuum tanks shall be constructed of stainless steel type 304L or equal for the following conditions:

External pressure Atmospheric Pressure
Internal pressure Full vacuum
Minimum Temperature 245 K
Maximum Temperature 320 K

3.2.3 Insulating Vacuum

Vacuum vessel shall be isolated by appropriate vacuum barriers and shall not require dynamic pumping. Each SPRF spool piece interface, Adit Transfer Line (ATL) interface and NDB interface shall have a vacuum barrier or stop.

Vacuum space shall be provided with a pumpout valve arranged for intermittent pumping. Seller shall furnish 4 inch vacuum valves, type *(tbd)* . Seller is not required to provide a pumping station for these lines. Gettering material in the vacuum space is acceptable. Vacuum retention shall be guaranteed for a period of one(1) year, by appropriate testing procedures.

The vacuum vessel shall be equipped with an over pressure relief valve. The capacity of the relief valve shall be such as to protect the vacuum casing from over pressure when subjected to the maximum delivery of process fluid, at system pressure, into the casing via a ruptured process line or expansion bellows. Materials such as multilayer insulation or other, used in the insulation system shall be restrained from entering and causing risk of plugging the relief vent area. Typically, a spring loaded relief valve or weighted hinged closure is acceptable.

Provisions for vacuum sensors, 1-inch Goddard fitting for a cold cathode gage and 1/8-inch FPT for a thermocouple gauge, shall be provided at each of the valve boxes. The Subcontractor is not required to furnish any vacuum instrumentation.

3.2.4 Compatibility:

The Subcontractor shall submit a list of the proposed equipment, such as pump out valves, etc. showing manufacturer and details of construction, to the SSCL with the proposal.

3.2.5 Heat Shield

The TDB shall have a thermal heat shield attached to the 80K line and having multilayer insulation (MLI) between it and the vacuum vessel (300K). Interior lines shall be separated by multilayer insulation. All valves and pipes that penetrate the vessel shell to room temperature shall be heat stationed to the heat shield and properly insulated from ambient temperatures.

3.3 Valve Requirements

Refer to Appendix *(tbd)* for valve assembly details and size restrictions.

Valving shall be designed for helium service at 4K and contain limit switches for open/closed position indication. Valve actuators..*(tbd)*.

Selection and sizing of valve assemblies shall be subject to SSCL review and approval.

Cold valves **(without LN_2 heat intercept)** in any helium system shall <u>not exceed</u> the following heat leak from ambient temperature to 4 K:

Valve Size	Heat Leak
(inches)	[Watts]
1/2, 3/4, 1	< 1.5
1-1/2	< 2.5
2	< 3.0
3	< 5.0
4	< 7.0

All cold valves for helium service shall incorporate a stainless-steel sealed bellows, a double seal, and a sample port for leak-checking the shaft spindle interspace. Instrument valves shall be standard single seal bellows type. Within the valve trim, the plug shall be removable and the seat shall be repairable in place if not removable. The bellows shall have a proven lifetime of at least 20,000 cycles. In addition, cold valves shall be designed to prevent thermal-acoustic oscillations.

All valves supplied as parts of the cryogenics system shall be stamped with flow arrows on the body and (if relevant) on the vacuum jacket.

All valve seals and trim shall be soft seat and, together with control plugs, shall be easily replaceable.

All valves except hand valves shall have a fail-safe position.

Sonic flow through valves is not acceptable for steady-state conditions.

3.4 Safety Devices

System shall have safety devices to meet applicable codes and regulations and protect personnel and equipment during malfunctions and fault conditions. The pressure-relief settings shall conform with the requirements given elsewhere in this specification and with the applicable standards. Unless otherwise stated, relief valve settings shall be a minimum of 2 bar or 10% above normal operating pressures, whichever is greater. Piping and system design shall meet or exceed the above relief valve pressure rating.

All volumes throughout the system which can be isolated with cryogenic fluids and / or have a potential for over pressure shall be equipped with relief valves.

Relief valve ports of vessels and chambers with multilayer insulation shall be screened to prevent inlet blockages.

All relief valves shall be easily demountable for inspection and resetting.

All pressure relief devices shall be located so that there is unobstructed access to them with a hot-air blower.

3.5 Vacuum, Leak Rate

The TDB shall be built to high vacuum standards.

a. All components shall have a demonstrated helium leak rate less than 1×10^{-9} mbar l/s, with the following exceptions:

   Demountable seals $<1\text{x}10^{-7}$ mbar l/s.
   Relief valves after repeated use (20 times) $<1\text{x}10^{-2}$ bar l/s

b. The helium leak rate shall be tested at 1 bar differential and ambient temperature conditions. The integral leak rate shall be demonstrated better than $1\text{x}10^{-7}$ mbar l/s.

c. Vendor shall submit leak-checking procedures before construction begins.

d. Connections in vacuum system shall be metallic rigid tube or flexible bellows.

e. Rubber and plastic hoses or fittings are not permitted in the vacuum system.

f. The subcontractor shall design and construct the equipment supplied in such a way that it can operate with total helium losses which do not exceed *(tbd)* per day and with no significant air leakage into vacuum over a period of six (6) months.

3.6 Cleaning, Surface Treatment

a. Cleaning of internal surfaces of piping, valves, and devices shall meet requirements for normal refrigeration/cryogenic equipment not exposed to liquid air or oxygen, ASTM A 380 - 88, Standard Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems. The subcontractor shall submit detailed cleaning procedures before construction starts.

b. All flux residue from brazed or soldered connections, all weld spackle and slag, and all sand and other particulates shall be removed. Systems shall be drained and purged of all solvents and any water from pressure tests and shall be thoroughly dried.

c. Visual inspection under bright and black light shall indicate no moisture, rust, foreign matter, film, or accumulation of oil, grease, or paint.

d. Cleaned internal surfaces shall have sufficient protection to maintain established cleanliness.

3.7 Instrumentation Requirements

3.7.1 Flow Meters

All flowmeters shall be the Venturi type . *(tbd)*

All flowmeters shown on P&ID drawings shall be supplied by the Subcontractor . The flowmeters shall be mounted in areas accessable to the manway ports. *(tbd)*. They shall be capable of resolution of 0.5% in the range of 20 g/s to 200 g/s with a differential pressure of 20" H20 at 4.3 K and 100 g/s. The differential pressure transducer shall be a *(tbd)* high line low differential transmitter or approved equal with an output as specified in Appendix II.

3 7.2 Temperature Sensors

The Subcontractor shall supply all temperature sensors to be installed in the system. They shall consist of carbon glass elements. Each thermometry position shall have at least two sensor elements mounted for reliability. All carbon glass elements may be treated as normal three wire elements. Since proper sensor mounting and heat sinking is of primary importance for accurate thermometry, a representative of the SSCL shall be present to observe the installation procedures described in *(tbd)*. Since each sensor is individually calibrated, accurate information shall be logged at the time of installation to assure the SSCL that the mounted sensor serial number and exact location are known.

The Temperature Sensor Mount Drawing *(tbd)* illustrates the method to be used by the Subcontractor to mount a temperature sensor.

The vacuum electrical feed-throughs shall be a hermetic feed-through compatible with an AN connector. The total number of wires shall be the sum of all the necessary leads for the items shown on the applicable P&ID drawing plus 4 spares.

All leads coming from the various temperature sensors are to be clearly marked, color coded and shown on a Seller furnished temperature sensor wiring diagram.

3.7.3 Pressure Taps and Sensors

All pressure taps shall be supplied by the Subcontractor per the P&ID drawing *(tbd)*

a. All process points are measured as static pressures. Wall tap shall be 4 mm or smaller in diameter, with a sharp, burr-free edge, installed normal to flow boundaries in straight tube or pipe sections. Combined pressure/temperature taps are not acceptable.

b. Pressure sensor connections shall be made with 300 series stainless steel tubes of 4 mm inside diameter. Wall thickness and overall length shall be optimized for minimal heat conduction with adequate weldablity at connection points. Instrument tubing shall be heat-stationed to the 80K heat shield.. Each line between process point and sensor (both low and high pressure lines in case of a differential pressure sensor) shall be equipped with a loop for vibration isolation and thermal stabilization, and shall have an external isolation valve. Differential pressure sensors shall also have a bypass valve.

c. Valved test ports shall be installed on all pressure sensors.

d. VCO style fittings shall be used on pressure sensing lines and test ports.

e. Unless the difference of two process points is measured, all pressure measurements shall be absolute.

f. Pressure sensors shall be capable of withstanding pressures to 150% of the maximum rated system pressure or 2 bar over the sensor's relief valve setting, whichever is greater, without requiring recalibration.

g. Pressure sensors shall not be mounted inside coldbox vacuum vessels, dewar vacuum jackets, or pipe vacuum jackets.

h. Pressure sensor loop accuracy shall meet or exceed the following full-scale specifications:

Accuracy	± 0.5%
Sensitivity	0.1%

Repeatability	0.1%
Stability	± 0.1%/yr

3.8 Performance Requirements

The drawings and appendices reflect required design elements of the TDB. The Subcontractor can deviate from the required design only with the written concurrence of the SSCL.

3.8.2 Heat Load Requirements

A heat load budget has been set for the TDB as follows:

10 ?? Watts into the 4K line

150 ?? Watts into the 80K line.

This includes valves, piping, supports, and any other contributors to the heat load by conduction, convection and/or radiation.

The Subcontractor shall provide, with the proposal, calculations supporting Sellers ability to meet these heat load budget figures. The Subcontractor shall submit at that time a list showing the estimated heat load of each piping run within the TDB including cryogenic valves which contribute to the heat load.

3.8.3 Pressure Drop Requirements

The line sizes *(tbd)* within the Collider N25 model TDB result in an acceptable pressure drop in the helium system. The Subcontractor shall not make changes that will result in an increase in the pressure drop of the system without written approval from the SSCL.

The allowed pressure drops are listed in Table 1.

When the design is complete, before fabrication begins, Seller shall submit, for Buyer's approval, a report which contains detailed calculations showing that the design conforms to the heat load and pressure drop requirement above.

Equipment provided must meet all of the Testing Requirements of Section (tbd)

3.9 Reliability and Availability Requirements

Collider operation is suspended whenever any Tunnel Distribution Box (TDB) fails. Failure is defined as the inability of the TDB to properly dispense and control the cryogens flowing though its lines. The TDB units are links within the cryogenic system that, by design, have no backup or bypass system to take over in case of failure. Also, the size and location of the TDB will not allow replacement of this device during any temporary or planned shutdown periods. Therefore reliability is of prime concern. Since there are few moving parts, mainly in the form of valve components, it is expected that the availability should be 100% throughout the life of the SSCL.

Reliability, maintainability, and availability allocations for all the collider subsystems are given in SSCL document *(tbd)*

Failure mode analysis is required to be performed by the offeror. Fault tree analysis is required to show *(tbd)*

The offeror shall supply a schedule for the anticipated accelerator non-operating periodic maintenance required to produce the described level of availability.

4.0 Quality Assurance Requirements

(tbd)

5.0 Preparation for Delivery

(tbd)

6.0 Notes

(tbd)

Filename: TDBOX.DOC
Directory: B:
Template: D:\WINWORD\NORMAL.DOT
Title: tunnel distribution box
Author: Don Finan
Subject:
Keywords:
Comments:
Create Date: 08/25/93 05:12 PM
Revision Number: 6
Last Saved Date: 08/31/93 11:38 AM
Last Saved By: Don Finan
Total Editing Time: 135 Minutes
Last Printed: 04/06/94 10:14 AM
As of Last Complete Printing
  Number of Pages: 22
  Number of Words: 4,229
  Number of Characters: 27,305

STATEMENT OF WORK (SOW)

FOR THE

UNDERGROUND DISTRIBUTION BOX
FABRICATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Production Readiness Review (PRR) 3
3.3 Fabrication 4
3.3.1 Schedule 4
3.3.2 Shop Witness Points 4
3.3.3 Material Control 5
3.3.4 Processes and Methods 5
3.3.5 Testing 5
3.3.6 Spares 6
3.3 Reserved 6
3.4 Reserved 6
3.5 Program Management 6
3.5.1 Contract Work Breakdown Structure (CWBS) 6
3.5.2 Lower Tier Subcontract Management 6
3.5.3 Program Schedules 7
3.5.4 Configuration Management (CM) and Control 7
3.5.5 System Safety 7
3.6 Quality Assurance 8
3.7 SSCL Numbering System 8
3.8 Units of Measure 8
3.9 Reserved 9
3.10 Management Reviews and Technical Meetings 9
3.10.1 Technical Interchange Meetings (TIM) 9
3.10.2 Resserved 9
3.11 Technical Reports 9
3.12 Cost Reports 9
4.0 Reserved 10
5.0 Customer Furnished Property/Services 10
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 11

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Underground Distribution Box (UDB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to fabricate eleven (11) Underground Distribution Box (UDB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the UDB are contained in the Product and Material Specifications for the Underground Distribution Box, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one UDB located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype UDB at N-15 of the SSC. The fabrication of eleven (11) production UDB, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to deliver production UDB, with accompanying data and spare parts, in accrodance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Maintenance of the design baseline established under the basic contract.

b. Conduct of a Production Readiness Review (PRR).

C. Fabrication of eleven (11) production UDB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Underground Distribution Box

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

f. XXXXXXXXXX, Product Specification for the Underground Distribution Box.

g. XXXXXXXXXX, Material Specification for the Underground Distribution Box .

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

d. Subcontractor Configuration Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Underground Distribution Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting of the UDB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Configuration Management

f. Quality Assurance

g. Producibility

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 PRODUCTION READINESS REVIEW (PRR)

The subcontractor shall conduct a PRR no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that any UDB design problems encountered during development have been resolved, and that adequate documentation of technical readiness and anticipated production costs are available for production phase release. As a minimum, the following items shall be addressed:

a. Product design:

   1. Producibility,

   2. Review of design changes during first article build and install,

   3. Design validation for performance, reliability, and maintainability.

b. Plant capacity, skilled personnel, and training resources.

c. Production Engineering and Planning:

   1. Compatability of production schedule with delivery requirements,

2. Integration of manufacturing methods and processes with facilities, equipment, tooling, and layout.

d. Materials and purchased parts:

1. Completeness of bill of materials,

2. Identification of long lead items,

3. Adequacy of inventory control system.

4. Spare part requirements.

e. Quality Assurance.

f. Safety Program.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.3 FABRICATION

The subcontractor shall fabricate all components of eleven (11) production UDB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of the production units will be in accordance with Section F of the subcontract.

3.3.1 Schedule

The subcontractor shall maintain a fabrication schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.3.2 Shop Witness Points

The following witness points shall be included in the subcontractor's fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.3.3 Material Control

The subcontractor shall implement material control procedures in accordance with the UDB quality assurance program, UDB system specifications, and the Parts Qualification Plan approved under the basic contract.

3.3.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special fabrication processes required to satisfy the provisions of the UDB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.3.5 Testing

The subcontractor shall conduct a fabrication test program during fabrication and assembly of the UDB components. Tests required by the UDB specifications and the subcontractor's quality assurance program shall be included. The fabrication test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.3.2 and 3.3.4, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. (Note that this does not include acceptance tests). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.3.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the fabrication tasks defined by this SOW in accordance with the UDB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the UDB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of fabrication and installation processes. The subcontractor shall identify potential risk factors associated with fabrication, installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the UDB specifications.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the UDB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Resserved

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST

CONTRACT DATA REQUIREMENTS LIST

UNDERGROUND DISTRIBUTION BOX STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1, .2 3.10.1	As Req'd	No
2	Meeting Minutes	3.1, .2 3.10.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.3.5	FT 5D	No
19	Fabrication Test Report	3.3.5	As Req'd	No
20	Spare Parts List	3.3.6	PRR	No
27	Program Schedules	3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	Updates	Yes
29	Material Safety Data Sheets	3.5.5.2	Updates	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.3.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.3.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.3.6

CDRL 27 - Program Schedules

Reference SOW paragraph 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

<u>CDRL 29 - Material Safety Data Sheets</u>

Reference SOW paragraph 3.5.5.2

<u>CDRL 30 - Monthly Report</u>

Reference SOW paragraph 3.11

<u>CDRL 31 - Cost Reports</u>

Reference SOW paragraph 3.12

<u>CDRL 35 - Contract Work Breakdown Structure</u>

Reference SOW paragraph 3.5.1.

<u>CDRL 36 - Contractor Organization</u>

Reference SOW paragraph 3.5

<u>CDRL 37 - Lower Tier Subcontract Data</u>

Reference SOW paragraph 3.5.2

STATEMENT OF WORK (SOW)

FOR THE

UNDERGROUND DISTRIBUTION BOX
INSTALLATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Installation 3
3.2.1 Schedule 3
3.2.2 Witness Points 4
3.2.3 Processes and Methods 4
3.2.4 Testing 4
3.3 Program Management 5
3.3.1 Reserved 5
3.3.2 Reserved 5
3.3.3 Program Schedules 5
3.3.4 Reserved 5
3.3.5 System Safety 5
3.3.5.1 Safety Analysis 5
3.3.5.2 Material Safety Data Sheets (MSDS) 5
3.3.5.3 On-Site Activities 6
3.4 Quality Assurance 6
3.5 SSCL Numbering System 7
3.6 Units of Measure 7
3.7 Reserved 7
3.8 Management Reviews and Technical Meetings 7
3.8.1 Technical Interchange Meetings (TIM) 7
3.8.2 Resserved 7
3.9 Technical Reports 7
3.10 Cost Reports 8
4.0 Reserved 8
5.0 Customer Furnished Property/Services 8
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 9

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring the services required to install Underground Distribution Boxes (UDB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to install eleven (11) Underground Distribution Boxes (UDB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the UDB are contained in the Product and Material Specifications for the Underground Distribution Box, document numbers, XXXXXXXXXX and XXXXXXXXXX, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one UDB located in the cyogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype UDB at N-15 of the SSC. The installation of eleven (11) production UDB, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these services is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to perform the installations of production UDB in accordance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Conduct of a Start of Work Meeting

b. Installation of eleven (11) production UDB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. AHW–XXXXX.XXX Development Specification for the Underground Distribution Box

b. Accelerator Systems Division Safety and Health Program Manual

c. SSCL Practice D10-000003, Hazard Analysis Instructions

d. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

e. XXXXXXXXXX, Product Specification for the Underground Distribution Box.

f. XXXXXXXXXX, Material Specification for the Underground Distribution Box.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Underground Distribution Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting for the installation of the UDB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications and drawings

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Quality Assurance

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 INSTALLATION

The subcontractor shall install all components of eleven (11) production UDB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of installation services will be in accordance with Section F of the subcontract.

3.2.1 Schedule

The subcontractor shall maintain an installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Witness Points

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Functional tests.

b. Final pressure and temperature tests and vacuum leak checking.

3.2.3 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special installation processes required to satisfy the provisions of the UDB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.2.4 Testing

The subcontractor shall conduct a test program during installation and assembly of the UDB components. Tests required by the UDB specifications and the subcontractor's quality assurance program shall be included. The installation test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.2.2 and 3.2.3, above, the results shall be reported to URA within five (5) days of completion of the test.

(**CDRL No. 18** – Witnessed Installation Test Results)

The results of all installation tests, including witnessed tests, shall be compiled by the subcontractor in an Installation Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. (**Note that this does not include acceptance tests**). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(**CDRL No. 19** – Installation Test Report)

3.3 PROGRAM MANAGEMENT

The subcontractor shall manage the installation tasks defined by this SOW in accordance with the UDB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the UDB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(**CDRL No. 36**– Contractor Organization)

3.3.1 Reserved

3.3.2 Reserved

3.3.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.3.4 Reserved

3.3.5 System Safety

3.3.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of installation processes. The subcontractor shall identify potential risk factors associated with installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the UDB specifications.

(CDRL No. 28– Safety Analysis)

3.3.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.3.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.4 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.5 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.6 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the UDB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.7 RESERVED

3.8 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.8.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or

informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.8.2 Resserved

3.9 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.10 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

UNDERGROUND DISTRIBUTION BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.8.1	As Req'd	No
2	Meeting Minutes	3.1 3.8.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.2.4	FT 5D	No
19	Fabrication Test Report	3.2.4	As Req'd	No
27	Program Schedules	3.2.1 3.3.3	Monthly	No
28	Safety Analysis	3.3.5.1	Updates	Yes
29	Material Safety Data Sheets	3.3.5.2	Updates	Yes
30	Monthly Report	3.9	Monthly	No
31	Cost Reports	3.10	Monthly	No
36	Contractor Organization	3.3	CA 30D	No

<u>Delivery Examples</u>- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes froi submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.4

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.4

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.3.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.3.5.2

<u>CDRL 30 - Monthly Report</u>

Reference SOW paragraph 3.9

<u>CDRL 31 - Cost Reports</u>

Reference SOW paragraph 3.10

<u>CDRL 36 - Contractor Organization</u>

Reference SOW paragraph 3.3

STATEMENT OF WORK (SOW)

FOR THE

UNDERGROUND DISTRIBUTION BOX

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Underground Distribution Box Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.1 Start of Work Meeting 4
3.1.2.2 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 6
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.4.3 Interface Control Documents (ICD) 7
3.2 Fabrication and Installation 7
3.2.1 Schedule 7
3.2.2 Shop/Field Witness Points 8
3.2.3 Material Control 8
3.2.4 Processes and Methods 8
3.2.5 Testing 8
3.2.6 Spares 9
3.2.7 Reserved 9
3.2.8 Installation 9
3.2.9 Maintenance Manual 9
3.3 Reserved 10
3.4 Reserved 10
3.5 Program Management 10
3.5.1 Contract Work Breakdown Structure (CWBS) 10
3.5.2 Lower Tier Subcontract Management 10
3.5.3 Program Schedules 11
3.5.4 Configuration Management (CM) and Control 11
3.5.5 System Safety 11

3.5.5.1 Safety Analysis 11
3.5.5.2 Material Safety Data Sheets (MSDS) 11
3.5.5.3 On-Site Activities 12
3.6 Quality Assurance 12
3.7 SSCL Numbering System 12
3.8 Units of Measure 12
3.9 Reserved 13
3.10 Management Reviews and Technical Meetings 13
3.10.1 Technical Interchange Meetings (TIM) 13
3.10.2 Technical Reviews 13
3.11 Technical Reports 13
3.12 Cost Reports 14
4.0 Reserved 14
5.0 Customer Furnished Property/Services 14
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 15

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Underground Distribution Boxes (UDB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, and install one prototype Underground Distribution Box (UDB) at N15 of the Superconducting Super Collider Laboratory (SSCL).

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one UDB located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. Technical and functional descriptions of the UDB are contained in AHW-XXXXX.XXX, Development Specification for the Underground Distribution Box.

Procurement of this prototype UDB is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objectives of this procurement are to deliver a production design with accompanying data and program management services, fabricate a prototype UDB, and install the prototype at site N-15 to support collider cooldown testing.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the UDB design requirements baseline in the form of a product fabrication specification and drawing package.

b. Present the design trade-offs, product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Fabricate the prototype UDB.

d. Installation and acceptance testing at the N-15 site of the SSC.

e. Maintenance and support of the prototype UDB during cool down testing at SSC.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan
b. AHW-XXXXX.XXX Development Specification for the Underground Distribution Box
c. Accelerator Systems Division Safety and Health Program Manual
d. SSCL Practice D10-000003, Hazard Analysis Instructions
e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System
b. Subcontractor Quality Assurance Plan (to be submitted with proposal)
c. Subcontractor Program Management Plan (to be submitted with proposal)
d. Subcontractor Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Development Specification for the Underground Distribution Box.

3.1 UNDERGROUND DISTRIBUTION BOX DESIGN

The subcontractor shall design the UDB in accordance with the requirements of the Development Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Sections 3, 4 and 5.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the UDB. The equipment design shall be fully documented in accordance with the Development Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Development Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted not later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.1 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the UDB not later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Development Specification

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Interfaces

f. Design standardization and maintenance

g. Program Management Plan

h. Quality Assurance Plan

i. Configuration Management Plan

j. Program risk assessment

k. Problems and concerns

l. Test Planning

m. SSC Test Support

n. Installation planning

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.1.2.2 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the UDB not later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the UDB design has been completed. As a minimum, the following items shall be addressed:

a. Design

b. Interfaces

c. Drawings, Level 2

d. Specifications

e. Configuration Management

f. Acceptance Test Planning

g. Test Support Planning

h. System safety

i. Fabrication planning

j. Quality Assurance planning

k. Installation planning

l. Failure modes analysis (FMA)

m. Logistics

   1. Transportation, packaging, and handling
   2. Standardization
   3. Special tools and equipment requirements
   4. Spares requirements

n. Program and near term schedules.

o. Program risk assessments

p. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings, Level 2)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11- Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the UDB and replacement modules shall be consistent with the Development Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on UDB performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post-replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 - Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL-STD-490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Development Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11-Product Specification (C2b))

(CDRL No. 15-Process Specifications)

(CDRL No. 21 - Material Specifications)

3.1.4.2 Drawings

The subcontractor shall convert design requirements into practical design layouts (Level 1) and then convert design layouts into detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 -As Built Drawings)

3.1.4.3 Interface Control Documents (ICD)

The subcontractor shall support URA in producing the appropriate interface control document(s).

(CDRL No. 32- Interface Control Documents)

3.2 FABRICATION AND INSTALLATION

The subcontractor shall fabricate and install all components of the prototype UDB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work.

3.2.1 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Shop/Field Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop/Field functional tests.

b. Final shop/field pressure and temperature tests and vacuum leak checking.

3.2.3 Material Control

The subcontractor shall implement material control procedures in accordance with the UDB quality assurance program and UDB specifications. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 - Parts Qualification Plan)

3.2.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the UDB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 - Process Specifications)

3.2.5 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the UDB components including all field assembly tasks. Tests required by the UDB specifications and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria,

b. Identification of equipment and supplies required,

c. Detailed test procedure,

d. Form(s) for reporting the test results.

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.4, above, or Section 3.2.10, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 - Fabrication Test Plan)

(CDRL No. 18 - Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 - Fabrication Test Report)

3.2.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 - Spare Parts List)

3.2.7 Reserved

3.2.8 Installation

The prototype UDB shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the UDB specifications and in this Statement of Work. This SOW considers installation tasks to include fabrication tasks accomplished in the field.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and leak checks.

3.2.9 Maintenance Manual

Prior to installation of the prototype UDB, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure. The manual shall include a list of all spares and equipment required for maintenance.

(CDRL No. 41- Maintenance Manual)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, and installation tasks defined by this SOW in accordance with the UDB Program Management Plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the UDB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36- *Contractor Organization*)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37- Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27- Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28- Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29- Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the UDB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work**, with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA in accordance with Section F of the subcontract. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Reviews shall be held at the subcontractor's facility on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30- Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31- Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

TBD

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

UNDERGROUND DISTRIBUTION BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2 3.10.1,.2	As Req'd	No
2	Meeting Minutes	3.1.2.1,.2, 3.10.1,.2	As Req'd	Yes
5	Drawings, Level 2	3.1.2.2	30D CDR	Yes
7	Reliability Analysis	3.1.2.2 3.1.3.1	CDR	Yes
8	Failure Modes Analysis	3.1.2.2 3.1.3.2	CDR	Yes
10	Maintainability Program Plan	3.1.2.2	CDR	Yes
11	Product Specifications	3.1.2.2 3.1.4.1	30D CDR	Yes
12	As Built Drawings	3.1.4.2	As Req'd	Yes
14	Parts Qualification Plan	3.2.3	60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.4	CDR 60D	Yes
17	Fabrication Test Plan	3.2.5	As Req'd	Yes
18	Witnessed Fabrication Test Results	3.2.5	FT 5D	No
19	Fabrication Test Report	3.2.5	As Req'd	No
20	Spare Parts List	3.2.6	60D Install	No
21	Material Specifications	3.1.4.1	CDR 60D	Yes
23	Acceptance Test Plan	3.1.2.2	CDR	Yes

27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.1.4.3	As Req'd	Yes
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
41	Maintenance Manual	3.2.9	120D Install	Yes

Delivery Examples- CA 30D = 30 days after Contract Award, 30D CDR = 30 days before CDR

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,
b. name(s) of meeting chairperson(s) or person calling the meeting,
c. schedule of items to be discussed and presenters,
b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,
b. discussion of each pertinent agenda item,
c. recommendations provided by both subcontractor and URA,
d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 5 - Drawings, Level 2

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,
b. probability of occurrence of each failure mode,
c. times during operation the failure mode can occur,
d. classification of the failure mode (critical, major, minor),
e. end item reliability when the failure occurs,
f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

CDRL 11 - Product Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 12 - As Built Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 14 - Parts Qualification Plan

The plan shall contain, but is not limited to ,the following

a. *the inspections and tests necessary to qualify the part,*

b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,

c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,

d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,

e. and the data to be recorded.

CDRL 15 - Process Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 17 - Fabrication Test Plan

Reference SOW paragraph 3.2.5

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 21 - Material Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program using a block diagram portrayal of the functions that must be met to satisfy the total acceptance program,
2. Milestones. Identifies the start and expected completion dates of each test to be performed,
3. Participation. Identifies the contractor and URA participation roles and responsibilities,
4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,
2. Number for each piece of equipment or item test will be performed,
3. Name and brief description of test to be performed,
4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;
2. All support equipment by description, nomenclature and serial number;

3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative

terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,

b. Time allocated for each topic of instruction,

c. Scheduled order of presentation,

d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

COLD COMPRESSOR BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2,.3,.4 3.10.1,.2,.3	As Req'd	No
2	Meeting Minutes	3.1.2.1,.2,.3,.4 3.10.1,.2,.3	As Req'd	No
3	Development Specifications	3.1.2.2 3.1.4.1	30D PDR	Yes
4	Reserved			
5	Drawings	3.1.2.2,.3	*	Yes
6	Reserved			
7	Reliability Analysis	3.1.2.2,.3 3.1.3.1	*	Yes
8	Failure Modes Analysis	3.1.2.2,.3 3.1.3.2	*	Yes
10	Maintainability Program Plan	3.1.2.3	CDR	Yes
11	Product Specifications	3.1.2.3 3.1.4.1	30D CDR	Yes
12	Reserved			
14	Parts Qualification Plan	3.2.4	60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.5	60D Fab	Yes
17	Fabrication Test Plan	3.2.6	60D FT	Yes
18	Witnessed Fabrication Test Results	3.2.6	FT 5D	No
19	Fabrication test Report	3.2.6	LFT 30D	No
20	Spare Parts List	3.2.7	60D Install	No
21	Long Lead List	3.2.8	30D PO	No

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
22	Calibration Database	3.4.2	30D Comm	No
23	Acceptance Test Plan (ATP)	3.1.2.2,.4	**	Yes
25	Reserved			
26	Acceptance Test Report	3.1.5	AT 10D	No
27	Program Schedules	3.2.2 3.3.3 3.5.3	30D PDRR Updates As Req'd	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.13	As Req'd	Yes
35	Operating Manual	3.4.3	30D CDR	Yes
36	Contractor Organization	3.5	CA 60D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
40	Training Syllabus	3.4.5	120D Comm	Yes
41	Maintenance Manual	3.4.7	120D Comm	Yes

* - Level 1 due 30D PDR and Level 3 due 30D CDR
** - Drafts due at PDR and finals due at CDR

Example- 30D PDR = Thirty days prior to PDR, CA 60D = Sixty days after Contract Award

Acornyms / Abbreviations Defined

PDR - Preliminary Design Review
AT - Acceptance Test
Fab - Fabrication of first unit
Install - Installation of first unit
PO - Purchase Order

CDR - Critical Design Review
FT - Fabrication Test
LFT - Last Fabrication Test
Comm - Commissioning of first unit
CA - Contract Award

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,
b. name(s) of meeting chairperson(s) or person calling the meeting,
c. schedule of items to be discussed and presenters,
b. and action assignments and status from previous meeting.

CDRL 1 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,
b. discussion of each pertinent agenda item,
c. recommendations provided by both subcontractor and URA,
d. one set of all presentation materials,
e. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 3 - Development Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 4 - Wiring/Connection Diagrams

Provide wiring connection and interconnection diagrams, charts, lists that contain complete identifying information for all signal, power, and control wiring. This data supplements logic and schematic drawings and must be adequate to allow rapid tracing of wiring from any one electronic/electrical connector to any other connector located within the component or system.

CDRL 5 - Electrical Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 6 - Mechanical Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,
b. probability of occurrence of each failure mode,
c. times during operation the failure mode can occur,
d. classification of the failure mode (critical, major, minor),
e. end item reliability when the failure occurs,
f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

CDRL 11 - Product Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 12 - As Built Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 14 - Parts Qualification Plan

The plan shall contain, but is not limited to ,the following

a. the inspections and tests necessary to qualify the part,

b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,
c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,
d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,
e. and the data to be recorded.

CDRL 15 - Process Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 17 - Fabrication Test Plan

Reference SOW paragraph 3.2.6

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.6

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.6

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.7

CDRL 21 - Long Lead List

Report includes a list of those items which, because of their complexity of design, complicated manufacturing process or limited production capacity, may cause production or procurement cycles which would preclude timely and adequate delivery, if not ordered in advance of normal provisioning.

CDRL 22 - Calibration Database

The calibration and measurement requirements summary shall document the measurement requirements of the system, subsystem, or equipment; the test, measurement, and diagnostic equipment; and the calibration standards and equipment required to assure traceability of all approved national standards.

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program using a block diagram portrayal of the functions that must be met to satisfy the total acceptance program,
2. Milestones. Identifies the start and expected completion dates of each test to be performed,
3. Participation. Identifies the contractor and URA participation roles and responsibilities,
4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,
2. Number for each piece of equipment or item test will be performed,
3. Name and brief description of test to be performed,
4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;
2. All support equipment by description, nomenclature and serial number;
3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 25 - Commissioning Acceptance Test Plan

Reference SOW paragraph 3.4.2

CDRL 26 - Acceptance Test Report

Complete report of the results of the Acceptance Test performed against the approved ATP. Report shall include all the collected data and all conclusions resulting form tests. The test report must be certified by the signature of a responsible project representative of the subcontractor.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program. Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Operating Manual

Manual shall include a description of the equipment with instructions for effective use, including one or more of the following sections as required:

a. instructions covering initial preparation for use,
b. operational instructions,
c. parts list,
d. and any related technical information.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,
b. Time allocated for each topic of instruction,
c. Scheduled order of presentation,
d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN SUBCOOLER BOX
FABRICATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Production Readiness Review (PRR) 3
3.3 Fabrication 4
3.3.1 Schedule 4
3.3.2 Shop Witness Points 4
3.3.3 Material Control 5
3.3.4 Processes and Methods 5
3.3.5 Testing 5
3.3.6 Spares 6
3.3 Reserved 6
3.4 Reserved 6
3.5 Program Management 6
3.5.1 Contract Work Breakdown Structure (CWBS) 6
3.5.2 Lower Tier Subcontract Management 6
3.5.3 Program Schedules 7
3.5.4 Configuration Management (CM) and Control 7
3.5.5 System Safety 7
3.6 Quality Assurance 8
3.7 SSCL Numbering System 8
3.8 Units of Measure 8
3.9 Reserved 9
3.10 Management Reviews and Technical Meetings 9
3.10.1 Technical Interchange Meetings (TIM) 9
3.10.2 Resserved 9
3.11 Technical Reports 9
3.12 Cost Reports 9
4.0 Reserved 10
5.0 Customer Furnished Property/Services 10
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 11

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Nitrogen Subcooler Box (NSB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to fabricate eleven (11) Nitrogen Subcooler Box (NSB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the NSB are contained in the Product and Material Specifications for the Nitrogen Subcooler Box, document numbers, XXXXXXXXXX and XXXXXXXXXX, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one NSB located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype NSB at N-15 of the SSC. The fabrication of eleven (11) production NSB, two (2) for the HEB and nine (9) for the SSC, is included in this contract.

Procurement of these systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to deliver production NSB, with accompanying data and spare parts, in accrodance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Maintenance of the design baseline established under the basic contract.

b. Conduct of a Production Readiness Review (PRR).

c. Fabrication of eleven (11) production NSB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Nitrogen Subcooler Box

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

f. XXXXXXXXXX, Product Specification for the Nitrogen Subcooler Box.

g. XXXXXXXXXX, Material Specification for the Nitrogen Subcooler Box.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

d. Subcontractor Configuration Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Nitrogen Subcooler Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting of the NSB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Configuration Management

f. Quality Assurance

g. Producibility

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 PRODUCTION READINESS REVIEW (PRR)

The subcontractor shall conduct a PRR no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that any TL system design problems encountered during development have been resolved, and that adequate documentation of technical readiness and anticipated production costs are available for production phase release. As a minimum, the following items shall be addressed:

a. Product design:

   1. Producibility,

   2. Review of design changes during first article build and install,

   3. Design validation for performance, reliability, and maintainability.

b. Plant capacity, skilled personnel, and training resources.

c. Production Engineering and Planning:

   1. Compatability of production schedule with delivery requirements,

2. Integration of manufacturing methods and processes with facilities, equipment, tooling, and layout.

d. Materials and purchased parts:

1. Completeness of bill of materials,

2. Identification of long lead items,

3. Adequacy of inventory control system.

4. Spare part requirements.

e. Quality Assurance.

f. Safety Program.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.3 FABRICATION

The subcontractor shall fabricate all components of eleven (11) production NSB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of the production units will be in accordance with Section F of the subcontract.

3.3.1 Schedule

The subcontractor shall maintain a fabrication schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.3.2 Shop Witness Points

The following witness points shall be included in the subcontractor's fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.3.3 Material Control

The subcontractor shall implement material control procedures in accordance with the NSB quality assurance program, NSB system specifications, and the Parts Qualification Plan approved under the basic contract.

3.3.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special fabrication processes required to satisfy the provisions of the NSB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.3.5 Testing

The subcontractor shall conduct a fabrication test program during fabrication and assembly of the NSB components. Tests required by the NSB specifications and the subcontractor's quality assurance program shall be included. The fabrication test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.3.2 and 3.3.4, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.3.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the fabrication tasks defined by this SOW in accordance with the NSB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NSB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of fabrication and installation processes. The subcontractor shall identify potential risk factors associated with fabrication, installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the NSB specificationd.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NSB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Resserved

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

NITROGEN SUBCOOLER BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1, .2 3.10.1	As Req'd	No
2	Meeting Minutes	3.1, .2 3.10.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.3.5	FT 5D	No
19	Fabrication Test Report	3.3.5	As Req'd	No
20	Spare Parts List	3.3.6	PRR	No
27	Program Schedules	3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	Updates	Yes
29	Material Safety Data Sheets	3.5.5.2	Updates	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.3.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.3.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.3.6

CDRL 27 - Program Schedules

Reference SOW paragraph 3.5.3

CDRL 28 - *Safety Analysis*

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN SUBCOOLER BOX
INSTALLATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope....1
1.1 Background....1
1.2 Objective....1
1.3 Summary of Subcontractor Activities....1
2.0 Applicable Documents....2
2.1 Reserved....2
2.2 SSCL Documents....2
2.3 Other Documents....2
3.0 Subcontractor Responsibilities....3
3.1 Start of Work Meeting....3
3.2 Installation....3
3.2.1 Schedule....3
3.2.2 Witness Points....4
3.2.3 Processes and Methods....4
3.2.4 Testing....4
3.3 Program Management....5
3.3.1 Reserved....5
3.3.2 Reserved....5
3.3.3 Program Schedules....5
3.3.4 Reserved....5
3.3.5 System Safety....5
3.3.5.1 Safety Analysis....5
3.3.5.2 Material Safety Data Sheets (MSDS)....5
3.3.5.3 On-Site Activities....6
3.4 Quality Assurance....6
3.5 SSCL Numbering System....7
3.6 Units of Measure....7
3.7 Reserved....7
3.8 Management Reviews and Technical Meetings....7
3.8.1 Technical Interchange Meetings (TIM)....7
3.8.2 Resserved....7
3.9 Technical Reports....7
3.10 Cost Reports....8
4.0 Reserved....8
5.0 Customer Furnished Property/Services....8
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST....9

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring the services required to install Nitrogen Subcooler Boxes (NSB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to install eleven (11) Nitrogen Subcooler Boxes (NSB) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the NSB are contained in the Product and Material Specifications for the Nitrogen Subcooler Box, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one NSB located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype NSB at N-15 of the SSC. The installation of eleven (11) production NSB, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these services is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to perform the installations of production NSB in accordance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Conduct of a Start of Work Meeting

b. Installation of eleven (11) production NSB.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. AHW-XXXXX.XXX Development Specification for the Nitrogen Subcooler Box

b. Accelerator Systems Division Safety and Health Program Manual

c. SSCL Practice D10-000003, Hazard Analysis Instructions

d. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

e. XXXXXXXXXX, Product Specification for the Nitrogen Subcooler Box.

f. XXXXXXXXXX, Material Specification for the Nitrogen Subcooler Box.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Nitrogen Subcooler Box.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting for the installation of the NSB no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications and drawings

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Quality Assurance

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 INSTALLATION

The subcontractor shall install all components of eleven (11) production NSB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of installation services will be in accordance with Section F of the subcontract.

3.2.1 Schedule

The subcontractor shall maintain an installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Witness Points

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Functional tests.

b. Final pressure and temperature tests and vacuum leak checking.

3.2.3 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special installation processes required to satisfy the provisions of the NSB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.2.4 Testing

The subcontractor shall conduct a test program during installation and assembly of the NSB components. Tests required by the NSB specifications and the subcontractor's quality assurance program shall be included. The installation test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.2.2 and 3.2.3, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 – Witnessed Installation Test Results)

The results of all installation tests, including witnessed tests, shall be compiled by the subcontractor in an Installation Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. (Note that this does not include acceptance tests). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Installation Test Report)

3.3 PROGRAM MANAGEMENT

The subcontractor shall manage the installation tasks defined by this SOW in accordance with the NSB program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NSB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.3.1 **Reserved**

3.3.2 **Reserved**

3.3.3 **Program Schedules**

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.3.4 **Reserved**

3.3.5 **System Safety**

3.3.5.1 **Safety Analysis**

The subcontractor shall ensure that safety is an inherent part of installation processes. The subcontractor shall identify potential risk factors associated with installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the NSB specifications.

(CDRL No. 28– Safety Analysis)

3.3.5.2 **Material Safety Data Sheets (MSDS)**

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.3.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.4 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.5 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.6 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NSB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.7 RESERVED

3.8 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.8.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or

informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.8.2 Resserved

3.9 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.10 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

NITROGEN SUBCOOLER BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.8.1	As Req'd	No
2	Meeting Minutes 3.1	As Req'd 3.8.1	No	
18	Witnessed Fabrication Test (FT) Results	3.2.4	FT 5D	No
19	Fabrication Test Report	3.2.4	As Req'd	No
27	Program Schedules	3.2.1 3.3.3	Monthly	No
28	Safety Analysis	3.3.5.1	Updates	Yes
29	Material Safety Data Sheets	3.3.5.2	Updates	Yes
30	Monthly Report	3.9	Monthly	No
31	Cost Reports	3.10	Monthly	No
36	Contractor Organization	3.3	CA 30D	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.4

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.4

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.3.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.3.5.2

<u>CDRL 30 - Monthly Report</u>

Reference SOW paragraph 3.9

<u>CDRL 31 - Cost Reports</u>

Reference SOW paragraph 3.10

<u>CDRL 36 - Contractor Organization</u>

Reference SOW paragraph 3.3

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN SUBCOOLER BOX

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 3
2.1 Military Specifications 3
2.2 SSCL Documents 3
2.3 Other Documents 3
3.0 Subcontractor Responsibilities 4
3.1 Nitrogen Subcooler Box Design 4
3.1.1 Equipment Design 4
3.1.2 Design Reviews 4
3.1.2.1 Start of Work Meeting 4
3.1.2.2 Critical Design Review (CDR) 5
3.1.3 Analysis 6
3.1.3.1 Reliability Analysis 6
3.1.3.2 Failure Modes Analysis (FMA) 6
3.1.4 Documentation 7
3.1.4.1 Specifications 7
3.1.4.2 Drawings 7
3.1.4.3 Interface Control Documents (ICD) 7
3.2 Fabrication and Installation 7
3.2.1 Schedule 7
3.2.2 Shop/Field Witness Points 8
3.2.3 Material Control 8
3.2.4 Processes and Methods 8
3.2.5 Testing 8
3.2.6 Spares 9
3.2.7 Reserved 9
3.2.8 Installation 9
3.2.9 Maintenance Manual 9
3.3 Reserved 10
3.4 Reserved 10
3.5 Program Management 10
3.5.1 Contract Work Breakdown Structure (CWBS) 10
3.5.2 Lower Tier Subcontract Management 10
3.5.3 Program Schedules 11
3.5.4 Configuration Management (CM) and Control 11
3.5.5 System Safety 11

3.5.5.1 Safety Analysis 11
3.5.5.2 Material Safety Data Sheets (MSDS) 11
3.5.5.3 On-Site Activities 12
3.6 Quality Assurance 12
3.7 SSCL Numbering System 12
3.8 Units of Measure 12
3.9 Reserved 13
3.10 Management Reviews and Technical Meetings 13
3.10.1 Technical Interchange Meetings (TIM) 13
3.10.2 Technical Reviews 13
3.11 Technical Reports 13
3.12 Cost Reports 14
4.0 Reserved 14
5.0 Customer Furnished Property/Services 14
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 15

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Nitrogen Subcooler Boxes (NSB) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, and install one prototype Nitrogen Subcooler Box (NSB) at N15 of the Superconducting Super Collider Laboratory (SSCL).

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one NSB located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. Technical and functional descriptions of the NSB are contained in AHW-XXXXX.XXX, Development Specification for the Nitrogen Subcooler Box.

Procurement of this prototype NSB is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objectives of this procurement are to deliver a production design with accompanying data and program management services, fabricate a prototype NSB, and install the prototype at site N-15 to support collider cooldown testing.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the NSB design requirements baseline in the form of a product fabrication specification and drawing package.

b. Present the design trade-offs, product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Fabricate the prototype NSB.

d. Installation and acceptance testing at the N-15 site of the SSC.

e. Maintenance and support of the prototype NSB during cool down testing at SSC.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Nitrogen Subcooler Box

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan (to be submitted with proposal)

c. Subcontractor Program Management Plan (to be submitted with proposal)

d. Subcontractor Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Development Specification for the Nitrogen Subcooler Box.

3.1 NITROGEN SUBCOOLER BOX DESIGN

The subcontractor shall design the NSB in accordance with the requirements of the Development Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Sections 3, 4 and 5.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the NSB. The equipment design shall be fully documented in accordance with the Development Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Development Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted not later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.1 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the NSB not later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Development Specification

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Interfaces

f. Design standardization and maintenance

g. Program Management Plan

h. Quality Assurance Plan

i. Configuration Management Plan

j. Program risk assessment

k. Problems and concerns

l. Test Planning

m. SSC Test Support

n. Installation planning

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.1.2.2 **Critical Design Review (CDR)**

The subcontractor shall conduct a CDR of the NSB not later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the NSB design has been completed. As a minimum, the following items shall be addressed:

a. Design

b. Interfaces

c. Drawings, Level 2

d. Specifications

e. Configuration Management

f. Acceptance Test Planning

g. Test Support Planning

h. System safety

i. Fabrication planning

j. Quality Assurance planning

k. Installation planning

l. Failure modes analysis (FMA)

m. Logistics

    1. Transportation, packaging, and handling

    2. Standardization

    3. Special tools and equipment requirements

    4. Spares requirements

n. Program and near term schedules.

o. Program risk assessments

p. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings, Level 2)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11– Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the NSB and replacement modules shall be consistent with the Development Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on NSB performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post–replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 – Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 Specifications

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL–STD–490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Development Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11-Product Specification (C2b))

(CDRL No. 15-Process Specifications)

(CDRL No. 21 - Material Specifications)

3.1.4.2 Drawings

The subcontractor shall convert design requirements into practical design layouts (Level 1) and then convert design layouts into detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 -As Built Drawings)

3.1.4.3 **Interface Control Documents (ICD)**

The subcontractor shall support URA in producing the appropriate interface control document(s).

(CDRL No. 32– Interface Control Documents)

3.2 FABRICATION AND INSTALLATION

The subcontractor shall fabricate and install all components of the prototype NSB in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work.

3.2.1 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Shop/Field Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop/Field functional tests.

b. Final shop/field pressure and temperature tests and vacuum leak checking.

3.2.3 Material Control

The subcontractor shall implement material control procedures in accordance with the NSB quality assurance program and NSB specifications. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 – Parts Qualification Plan)

3.2.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the NSB specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 – Process Specifications)

3.2.5 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the NSB components including all field assembly tasks. Tests required by the NSB specifications and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria,

b. Identification of equipment and supplies required,

c. Detailed test procedure,

d. Form(s) for reporting the test results.

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.4, above, or Section 3.2.10, below, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 17 – Fabrication Test Plan)

(CDRL No. 18 – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 – Fabrication Test Report)

3.2.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 – Spare Parts List)

3.2.7 Reserved

3.2.8 Installation

The prototype NSB shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the NSB specifications and in this Statement of Work. This SOW considers installation tasks to include fabrication tasks accomplished in the field.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and leak checks.

3.2.9 Maintenance Manual

Prior to installation of the prototype NSB, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure. The manual shall include a list of all spares and equipment required for maintenance.

(CDRL No. 41– Maintenance Manual)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, and installation tasks defined by this SOW in accordance with the NSB Program Management Plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NSB shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NSB and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA in accordance with Section F of the subcontract. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Reviews shall be held at the subcontractor's facility on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

TBD

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

NITROGEN SUBCOOLER BOX
STATEMENT OF WORK

CDRL	TITLE	SOW REF		DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2 3.10.1,.2		As Req'd	No
2	Meeting Minutes3.1.2.1,.2,	3.10.1,.2	As Req'd	Yes	
5	Drawings, Level 23.1.2.2		30D CDR	Yes	
7	Reliability Analysis	3.1.2.2 3.1.3.1		CDR	Yes
8	Failure Modes Analysis	3.1.2.2 3.1.3.2		CDR	Yes
10	Maintainability Program Plan	3.1.2.2		CDR	Yes
11	Product Specifications	3.1.2.2 3.1.4.1		30D CDR	Yes
12	As Built Drawings3.1.4.2		As Req'd	Yes	
14	Parts Qualification Plan	3.2.3		60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.4		CDR 60D	Yes
17	Fabrication Test Plan	3.2.5		As Req'd	Yes
18	Witnessed Fabrication Test Results	3.2.5		FT 5D	No
19	Fabrication Test Report	3.2.5		As Req'd	No
20	Spare Parts List	3.2.6		60D Install	No
21	Material Specifications	3.1.4.1		CDR 60D	Yes
23	Acceptance Test Plan	3.1.2.2		CDR	Yes

27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.1.4.3	As Req'd	Yes
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
41	Maintenance Manual	3.2.9	120D Install	Yes

Delivery Examples- *CA 30D = 30 days after Contract Award, 30D CDR = 30 days before CDR*

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 5 - Drawings, Level 2

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,

b. probability of occurrence of each failure mode,

c. times during operation the failure mode can occur,

d. classification of the failure mode (critical, major, minor),

e. end item reliability when the failure occurs,

f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

CDRL 11 - Product Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 12 - As Built Drawings

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 14 - Parts Qualification Plan

The plan shall contain, but is not limited to ,the following

a. the inspections and tests necessary to qualify the part,

b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,

c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,

d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,

e. and the data to be recorded.

CDRL 15 - Process Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 17 - Fabrication Test Plan

Reference SOW paragraph 3.2.5

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 21 - Material Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program block diagram portrayal of the functions that must be met to satisfy the total acceptance program,
2. Milestones. Identifies the start and expected completion dates of each test to be performed,
3. Participation. Identifies the contractor and URA participation roles and responsibilities,
4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,
2. Number for each piece of equipment or item test will be performed,
3. Name and brief description of test to be performed,
4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;
2. All support equipment by description, nomenclature and serial number;
3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.
Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,

b. Time allocated for each topic of instruction,

c. Scheduled order of presentation,

d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN DUMP TANKS
FABRICATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Production Readiness Review (PRR) 3
3.3 Fabrication 4
3.3.1 Schedule 4
3.3.2 Shop Witness Points 4
3.3.3 Material Control 5
3.3.4 Processes and Methods 5
3.3.5 Testing 5
3.3.6 Spares 6
3.3 Reserved 6
3.4 Reserved 6
3.5 Program Management 6
3.5.1 Contract Work Breakdown Structure (CWBS) 6
3.5.2 Lower Tier Subcontract Management 6
3.5.3 Program Schedules 7
3.5.4 Configuration Management (CM) and Control 7
3.5.5 System Safety 7
3.6 Quality Assurance 8
3.7 SSCL Numbering System 8
3.8 Units of Measure 8
3.9 Reserved 9
3.10 Management Reviews and Technical Meetings 9
3.10.1 Technical Interchange Meetings (TIM) 9
3.10.2 Resserved 9
3.11 Technical Reports 9
3.12 Cost Reports 9
4.0 Reserved 10
5.0 Customer Furnished Property/Services 10
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 11

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Nitrogen Dump Tanks (NDT) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to fabricate eleven (11) sets of two Nitrogen Dump Tanks (NDT) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the NDT are contained in the Product and Material Specifications for the Nitrogen Dump Tanks, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one set of two NDT located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype set of two NDT at N-15 of the SSC. The fabrication of eleven (11) sets of production NDT, two (2) for the HEB and nine (9) for the SSC, is included in this SOW.

Procurement of these systems is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to deliver production NDT, with accompanying data and spare parts, in accrodance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Maintenance of the design baseline established under the basic contract.

b. Conduct of a Production Readiness Review (PRR).

c. Fabrication of eleven (11) production sets of NDT.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW–XXXXX.XXX Development Specification for the Nitrogen Dump Tanks

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

f. XXXXXXXXXX, Product Specification for the Nitrogen Dump Tanks.

g. XXXXXXXXXX, Material Specification for the Nitrogen Dump Tanks.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

d. Subcontractor Configuration Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Nitrogen Dump Tanks.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting of the NDT no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Configuration Management

f. Quality Assurance

g. Producibility

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 PRODUCTION READINESS REVIEW (PRR)

The subcontractor shall conduct a PRR no later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that any NDT design problems encountered during development have been resolved, and that adequate documentation of technical readiness and anticipated production costs are available for production phase release. As a minimum, the following items shall be addressed:

a. Product design:

1. Producibility,

2. Review of design changes during first article build and install,

3. Design validation for performance, reliability, and maintainability.

b. Plant capacity, skilled personnel, and training resources.

c. Production Engineering and Planning:

1. Compatability of production schedule with delivery requirements,

2. Integration of manufacturing methods and processes with facilities, equipment, tooling, and layout.

d. Materials and purchased parts:

1. Completeness of bill of materials,

2. Identification of long lead items,

3. Adequacy of inventory control system.

4. Spare part requirements.

e. Quality Assurance.

f. Safety Program.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.3 FABRICATION

The subcontractor shall fabricate all components of eleven (11) sets of production NDT in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of the production units will be in accordance with Section F of the subcontract.

3.3.1 Schedule

The subcontractor shall maintain a fabrication schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.3.2 Shop Witness Points

The following witness points shall be included in the subcontractor's fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop functional tests.

b. Final shop pressure and temperature tests and vacuum leak checking.

3.3.3 Material Control

The subcontractor shall implement material control procedures in accordance with the NDT quality assurance program, NDT system specifications, and the Parts Qualification Plan approved under the basic contract.

3.3.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special fabrication processes required to satisfy the provisions of the NDT specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.3.5 Testing

The subcontractor shall conduct a fabrication test program during fabrication and assembly of the NDT components. Tests required by the NDT specifications and the subcontractor's quality assurance program shall be included. The fabrication test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.3.2 and 3.3.4, above, the results shall be reported to URA within five (5) days of completion of the test.

(**CDRL No. 18** – Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. (**Note that this does not include acceptance tests**). URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(**CDRL No. 19** – Fabrication Test Report)

3.3.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(**CDRL No. 20** – Spare Parts List)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the fabrication tasks defined by this SOW in accordance with the NDT program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NDT shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(**CDRL No. 36**– Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(**CDRL No. 35** - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(**CDRL No. 37**– Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(**CDRL No. 27**– Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of fabrication and installation processes. The subcontractor shall identify potential risk factors associated with fabrication, installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined *in the NDT specifications.*

(CDRL No. 28– Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NDT and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 – Meeting Agendas)
(CDRL No. 2 – Meeting Minutes)

3.10.2 Resserved

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30– Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31– Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

NITROGEN DUMP TANKS
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1, .2 3.10.1	As Req'd	No
2	Meeting Minutes 3.1, .2	As Req'd 3.10.1	No	
18	Witnessed Fabrication Test (FT) Results	3.3.5	FT 5D	No
19	Fabrication Test Report	3.3.5	As Req'd	No
20	Spare Parts List	3.3.6	PRR	No
27	Program Schedules	3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	Updates	Yes
29	Material Safety Data Sheets	3.5.5.2	Updates	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No

__Delivery Examples__- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based upon changes fro submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,

b. name(s) of meeting chairperson(s) or person calling the meeting,

c. schedule of items to be discussed and presenters,

b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,

b. discussion of each pertinent agenda item,

c. recommendations provided by both subcontractor and URA,

d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.3.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.3.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.3.6

CDRL 27 - Program Schedules

Reference SOW paragraph 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN DUMP TANKS
INSTALLATION

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
1.1 Background 1
1.2 Objective 1
1.3 Summary of Subcontractor Activities 1
2.0 Applicable Documents 2
2.1 Reserved 2
2.2 SSCL Documents 2
2.3 Other Documents 2
3.0 Subcontractor Responsibilities 3
3.1 Start of Work Meeting 3
3.2 Installation 3
3.2.1 Schedule 3
3.2.2 Witness Points 4
3.2.3 Processes and Methods 4
3.2.4 Testing 4
3.3 Program Management 5
3.3.1 Reserved 5
3.3.2 Reserved 5
3.3.3 Program Schedules 5
3.3.4 Reserved 5
3.3.5 System Safety 5
3.3.5.1 Safety Analysis 5
3.3.5.2 Material Safety Data Sheets (MSDS) 5
3.3.5.3 On-Site Activities 6
3.4 Quality Assurance 6
3.5 SSCL Numbering System 7
3.6 Units of Measure 7
3.7 Reserved 7
3.8 Management Reviews and Technical Meetings 7
3.8.1 Technical Interchange Meetings (TIM) 7
3.8.2 Resserved 7
3.9 Technical Reports 7
3.10 Cost Reports 8
4.0 Reserved 8
5.0 Customer Furnished Property/Services 8
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 9

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring the services required to install Nitrogen Dump Tanks (NDT) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to install eleven (11) Nitrogen Dump Tanks (NDT) for the Superconducting Super Collider Laboratory (SSCL). Technical requirements for the NDT are contained in the Product and Material Specifications for the Nitrogen Dump Tanks, document numbers, *XXXXXXXXXX* and *XXXXXXXXXX*, respectively.

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one set of two NDT located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. The basic contract called for the design, fabrication, and installation of a prototype set of two NDT at N-15 of the SSC. The installation of eleven (11) production sets of two NDT, two (2) sets of two for the HEB and nine (9) sets of two for the SSC, is included in this SOW.

Procurement of these services is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objective of this procurement is to perform the installations of production NDT in accordance with Section F of this subcontract on the schedule required to support collider operation.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Conduct of a Start of Work Meeting

b. Installation of eleven (11) production NDT.

2.0 APPLICABLE DOCUMENTS

2.1 RESERVED

2.2 SSCL DOCUMENTS

a. AHW-XXXXX.XXX Development Specification for the Nitrogen Dump Tanks

b. Accelerator Systems Division Safety and Health Program Manual

c. SSCL Practice D10-000003, Hazard Analysis Instructions

d. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

e. *XXXXXXXXXX*, Product Specification for the Nitrogen Dump Tanks.

f. *XXXXXXXXXX*, Material Specification for the Nitrogen Dump Tanks.

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan

c. Subcontractor Program Management Plan

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Specifications for the Nitrogen Dump Tanks.

3.1 START OF WORK MEETING

The subcontractor shall conduct a Start of Work Meeting for the installation of the NDT no later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Product and Material Specifications and drawings

b. Statement of Work

c. Contract Data Requirements List

d. Cost/Schedule

e. Quality Assurance

h. Installation

i. Safety Program

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.2 INSTALLATION

The subcontractor shall install all components of eleven (11) sets of two production NDT in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work. Delivery of installation services will be in accordance with Section F of the subcontract.

3.2.1 Schedule

The subcontractor shall maintain an installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Witness Points

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Functional tests.

b. Final pressure and temperature tests and vacuum leak checking.

3.2.3 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall maintain and follow written procedures for all special installation processes required to satisfy the provisions of the NDT specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.).

3.2.4 Testing

The subcontractor shall conduct a test program during installation and assembly of the NDT components. Tests required by the NDT specifications and the subcontractor's quality assurance program shall be included. The installation test program shall be conducted in accordance with the FTP submitted and approved under the basic contract.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria

b. Identification of equipment and supplies required

c. A detailed test procedure

d. Form(s) for reporting the test results

Test results shall be reported to URA. For each test for which a witness point has been identified in Sections 3.2.2 and 3.2.3, above, the results shall be reported to URA within five (5) days of completion of the test.

(CDRL No. 18 - Witnessed Installation Test Results)

The results of all installation tests, including witnessed tests, shall be compiled by the subcontractor in an Installation Test Report which shall be submitted to URA within thirty (30) days after completion of the last test for each unit. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. 19 - Installation Test Report)

3.3 PROGRAM MANAGEMENT

The subcontractor shall manage the installation tasks defined by this SOW in accordance with the NDT program management plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NDT shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36- Contractor Organization)

3.3.1 Reserved

3.3.2 Reserved

3.3.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(CDRL No. 27- Program Schedules)

3.3.4 Reserved

3.3.5 System Safety

3.3.5.1 Safety Analysis

The subcontractor shall ensure that safety is an inherent part of installation processes. The subcontractor shall identify potential risk factors associated with installation and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the NDT specifications.

(CDRL No. 28- Safety Analysis)

3.3.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(CDRL No. 29- Material Safety Data Sheets)

3.3.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.4 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.5 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.6 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NDT and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.7 RESERVED

3.8 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.8.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate program requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.8.2 Resserved

3.9 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30- Monthly Report)

3.10 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31- Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

CONTRACT DATA REQUIREMENTS LIST

NITROGEN DUMP TANKS
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1 3.8.1	As Req'd	No
2	Meeting Minutes	3.1 3.8.1	As Req'd	No
18	Witnessed Fabrication Test (FT) Results	3.2.4	FT 5D	No
19	Fabrication Test Report	3.2.4	As Req'd	No
27	Program Schedules	3.2.1 3.3.3	Monthly	No
28	Safety Analysis	3.3.5.1	Updates	Yes
29	Material Safety Data Sheets	3.3.5.2	Updates	Yes
30	Monthly Report	3.9	Monthly	No
31	Cost Reports	3.10	Monthly	No
36	Contractor Organization	3.3	CA 30D	No

Delivery Examples- CA 30D = 30 days after Contract Award, Updates = Revisions As Req'd based changes from Data submitted under the Basic Contract

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,
b. name(s) of meeting chairperson(s) or person calling the meeting,
c. schedule of items to be discussed and presenters,
b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,
b. discussion of each pertinent agenda item,
c. recommendations provided by both subcontractor and URA,
d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 18 - Witnessed Fabrication Test Results

Reference SOW paragraph 3.2.4

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.4

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.3.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.3.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.9

CDRL 31 - Cost Reports

Reference SOW paragraph 3.10

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.3

STATEMENT OF WORK (SOW)

FOR THE

NITROGEN DUMP TANKS

FOR THE
SUPERCONDUCTING SUPER COLLIDER
LABORATORY

DRAFT

March 28, 1994

TABLE OF CONTENTS

1.0 Scope 1
- 1.1 Background 1
- 1.2 Objective 1
- 1.3 Summary of Subcontractor Activities 1

2.0 Applicable Documents 3
- 2.1 Military Specifications 3
- 2.2 SSCL Documents 3
- 2.3 Other Documents 3

3.0 Subcontractor Responsibilities 4
- 3.1 Nitrogen Dump Tanks Design 4
  - 3.1.1 Equipment Design 4
  - 3.1.2 Design Reviews 4
    - 3.1.2.1 Start of Work Meeting 4
    - 3.1.2.2 Critical Design Review (CDR) 5
  - 3.1.3 Analysis 6
    - 3.1.3.1 Reliability Analysis 6
    - 3.1.3.2 Failure Modes Analysis (FMA) 6
  - 3.1.4 Documentation 7
    - 3.1.4.1 Specifications 7
    - 3.1.4.2 Drawings 7
    - 3.1.4.3 Interface Control Documents (ICD) 7
- 3.2 Fabrication and Installation 7
  - 3.2.1 Schedule 7
  - 3.2.2 Shop/Field Witness Points 8
  - 3.2.3 Material Control 8
  - 3.2.4 Processes and Methods 8
  - 3.2.5 Testing 8
  - 3.2.6 Spares 9
  - 3.2.7 Reserved 9
  - 3.2.8 Installation 9
  - 3.2.9 Maintenance Manual 9
- 3.3 Reserved 10
- 3.4 Reserved 10
- 3.5 Program Management 10
  - 3.5.1 Contract Work Breakdown Structure (CWBS) 10
  - 3.5.2 Lower Tier Subcontract Management 10
  - 3.5.3 Program Schedules 11
  - 3.5.4 Configuration Management (CM) and Control 11
  - 3.5.5 System Safety 11

3.5.5.1 Safety Analysis 11
3.5.5.2 Material Safety Data Sheets (MSDS) 11
3.5.5.3 On-Site Activities 12
3.6 Quality Assurance 12
3.7 SSCL Numbering System 12
3.8 Units of Measure 12
3.9 Reserved 13
3.10 Management Reviews and Technical Meetings 13
3.10.1 Technical Interchange Meetings (TIM) 13
3.10.2 Technical Reviews 13
3.11 Technical Reports 13
3.12 Cost Reports 14
4.0 Reserved 14
5.0 Customer Furnished Property/Services 14
ANNEX 1 - CONTRACT DATA REQUIREMENTS LIST 15

1.0 SCOPE

The Cryogenics Department of the Accelerator Systems Division (ASD) of the Superconducting Super Collider Laboratory (SSCL) is procuring Nitrogen Dump Tanks (NDT) for use in the High Energy Booster (HEB) and Super Collider rings. This Statement of Work (SOW) defines the work required by the subcontractor to design, fabricate, test, and install one prototype Nitrogen Dump Tanks (NDT) at N15 of the Superconducting Super Collider Laboratory (SSCL).

1.1 BACKGROUND

Universities Research Association (URA) is the prime contractor to the U. S. Department of Energy (DOE) for the Superconducting Super Collider (SSC) project. As such, URA is responsible for the overall design, development, production, construction, installation, operation, and maintenance of the SSC. The SSC requires cryogenic cooling in its High Energy Booster (HEB) and Super Collider (SC) rings. The HEB is approximately 80 feet underground while the SC is approximately 250 feet underground. The HEB is divided into two (2) sectors while the SC is divided into ten (10) sectors. Each sector has a refrigeration plant on the surface which supplies liquid helium to cool the strings of superconducting magnets in the sector.

There is one set of two NDT located in the cryogenic alcove at each of the 12 utility shafts; 2 for the HEB and 10 for the SSC. Technical and functional descriptions of the NDT are contained in AHW-XXXXX.XXX, Development Specification for the Nitrogen Dump Tanks.

This procurement is being arranged and coordinated by the Cryogenics Department of the Accelerator Systems Division (ASD) of the SSCL.

1.2 OBJECTIVE

The objectives of this procurement are to deliver a production design with accompanying data and program management services, fabricate one set of two prototype NDT, and install them at site N-15 to support collider cooldown testing.

1.3 SUMMARY OF SUBCONTRACTOR ACTIVITIES

The scope of work to be performed by the subcontractor includes but is not limited to the following:

a. Equipment design. Establish the NDT design requirements baseline in the form of a product fabrication specification and drawing package.

b. Present the design trade-offs, product specifications, process specifications, drawings and acceptance test procedures at the Critical Design Review. Approval of the specifications and drawings will establish the design baseline.

c. Fabricate the prototype NDT.

d. Installation and acceptance testing at the N-15 site of the SSC.

e. Maintenance and support of the prototype NDT during cool down testing at SSC.

2.0 APPLICABLE DOCUMENTS

2.1 MILITARY SPECIFICATIONS

a. DOD-Std-1000B Drawings, Engineering and Associated Lists
b. MIL-Std-490B Specification Practices

2.2 SSCL DOCUMENTS

a. SSCL Standard P40-000031 Configuration Management Plan

b. AHW-XXXXX.XXX Development Specification for the Nitrogen Dump Tanks

c. Accelerator Systems Division Safety and Health Program Manual

d. SSCL Practice D10-000003, Hazard Analysis Instructions

e. SSCL Laboratory Environment, Safety, and Health Manual, D10-00001

2.3 OTHER DOCUMENTS

a. DOE 5481.1B, Safety Analysis and Review System

b. Subcontractor Quality Assurance Plan (to be submitted with proposal)

c. Subcontractor Program Management Plan (to be submitted with proposal)

d. Subcontractor Configuration Management Plan (to be submitted with proposal)

3.0 SUBCONTRACTOR RESPONSIBILITIES

The subcontractor shall furnish all materials, labor, facilities, equipment, supplies, tools, documentation, management, and support services required to complete the tasks defined herein. The work shall be performed in accordance with this Statement of Work and the Development Specification for the Nitrogen Dump Tanks.

3.1 NITROGEN DUMP TANKS DESIGN

The subcontractor shall design the NDT in accordance with the requirements of the Development Specification and in compliance with the general requirements of documents specified in this Statement of Work under Sections 2.2 (SSCL Documents) and 2.3 (Other Documents), and the specific tasking of Sections 3, 4 and 5.

3.1.1 Equipment Design

The subcontractor shall be responsible for the complete design and/or selection of all equipment comprising the NDT. The equipment design shall be fully documented in accordance with the Development Specification and Section 3.1.4 of this SOW to permit verification of conformance to the Development Specification.

The design of any item of equipment or any assembly shall be considered complete upon approval by URA of all related drawings and any additional design documentation required by this SOW (specifications, calculations, test results, etc.). At that time the subcontractor shall be released to begin procurement and/or fabrication of the item or assembly. All equipment design documentation shall be completed by the Critical Design Review (CDR). The status of in-progress designs shall be presented to URA at scheduled reviews per Section 3.1.2 of this SOW.

3.1.2 Design Reviews

The design and planning efforts of the subcontractor shall be presented to URA at the reviews described herein. Reviews shall be conducted not later than the dates specified in Section F of the Subcontract, and each review shall be included as a milestone in the subcontractor's schedule.

3.1.2.1 Start of Work Meeting

The subcontractor shall conduct a Start of Work Meeting of the NDT not later than the date specified in Section F of the Subcontract. The purpose of this meeting is to clarify the requirements with the subcontractor. As a minimum, the following items shall be addressed:

a. Development Specification
b. Statement of Work
c. Contract Data Requirements List
d. Cost/Schedule
e. Interfaces
f. Design standardization and maintenance
g. Program Management Plan
h. Quality Assurance Plan
i. Configuration Management Plan
j. Program risk assessment
k. Problems and concerns
l. Test Planning
m. SSC Test Support
n. Installation planning

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.1.2.2 Critical Design Review (CDR)

The subcontractor shall conduct a CDR of the NDT not later than the date specified in Section F of the Subcontract. The purpose of this review is to obtain URA concurrence that the NDT design has been completed. As a minimum, the following items shall be addressed:

a. Design
b. Interfaces
c. Drawings, Level 2
d. Specifications
e. Configuration Management
f. Acceptance Test Planning
g. Test Support Planning
h. System safety
i. Fabrication planning
j. Quality Assurance planning
k. Installation planning

l. Failure modes analysis (FMA)

m. Logistics

   1. Transportation, packaging, and handling
   2. Standardization
   3. Special tools and equipment requirements
   4. Spares requirements

n. Program and near term schedules.

o. Program risk assessments

p. Problems and concerns.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)
(CDRL No. 5 - Drawings, Level 2)
(CDRL No. 10- Maintainability Program Plan)
(CDRL No. 8 - Failure Modes Analysis)
(CDRL No. 11- Product Specifications)
(CDRL No. 7 - Reliability Analysis)
(CDRL No.23 - Acceptance Test Plan)

3.1.3 Analysis

3.1.3.1 Reliability Analysis

The subcontractor shall prepare a reliability block diagram and reliability prediction. The block diagram shall be complete to an indenture level that reflects the modular replacements anticipated to occur on-site and shall reflect failures identified in the failure modes analysis defined in Section 3.1.3.2 of this SOW.

The reliability predictions for the NDT and replacement modules shall be consistent with the Development Specification.

(CDRL No. 7 - Reliability Analysis)

3.1.3.2 Failure Modes Analysis (FMA)

The subcontractor shall perform a failure modes analysis to determine the effect of component failures on NDT performance and supportability. For the purposes of this analysis **component** is defined to be an item that is recommended for replacement by the URA-approved maintenance concept. **Subcomponent** repair activities carried out post-replacement in a different facility are beyond the scope of this analysis. Results of this analysis shall be presented to URA in the form of a report. This analysis shall include: a description of the failure modes, causes of failure, probable effects of failure, probability of occurrence, criticality of failure, a list of any safety implications, and corrective actions or preventive measures. The subcontractor shall provide recommendations for mitigating the impact of failures through design improvements, tests, and inspections.

(CDRL No. 8 - Failure Modes Analysis)

3.1.4 Documentation

3.1.4.1 **Specifications**

The subcontractor shall provide a Critical Item Fabrication Product Specification, (Type C2b per MIL-STD-490B) for equipment produced on this contract, in sufficient detail to allow verification of compliance with the Development Specification and to support maintenance and reprocurement actions. Product, process and material specifications shall be included. For commercial equipment, commercial specifications shall suffice.

(CDRL No. 11-Product Specification (C2b))

(CDRL No. 15-Process Specifications)

(CDRL No. 21 - Material Specifications)

3.1.4.2 **Drawings**

The subcontractor shall convert design requirements into practical design layouts (Level 1) and then convert design layouts into detailed drawings (Level II). The subcontractor shall produce all final drawings in a format compatible with DOD-STD-1000B, Level II. For commercial equipment, commercial drawings shall suffice.

The subcontractor shall prepare as-built drawings for any item, component, module, etc., which deviates from design or fabrication drawing specifications, or which is cut- or built-to-fit in the shop or field. These drawings shall be submitted to URA within fourteen (14) days after completion of the fabrication and/or installation of the item.

(CDRL No. 12 -As Built Drawings)

3.1.4.3 **Interface Control Documents (ICD)**

The subcontractor shall support URA in producing the appropriate interface control document(s).

(CDRL No. 32- Interface Control Documents)

3.2 FABRICATION AND INSTALLATION

The subcontractor shall fabricate and install all components of the prototype set of two NDT in accordance with the approved program management plan and the applicable codes, standards, URA approved specifications, and the requirements of this Statement of Work.

3.2.1 Schedule

The subcontractor shall maintain a fabrication and installation schedule for all components delineating milestones, witness points, testing, and shipping dates. This schedule shall be in accordance with Section F of this subcontract. This schedule shall be maintained as an integral part of the program schedule described in Section 3.5.3.

(CDRL No. 27-Program Schedules)

3.2.2 Shop/Field Witness Points

The following witness points shall be included in the subcontractor's prototype fabrication schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Shop/Field functional tests.

b. Final shop/field pressure and temperature tests and vacuum leak checking.

3.2.3 Material Control

The subcontractor shall implement material control procedures in accordance with the NDT quality assurance program and NDT specifications. Material qualification records (certified material test reports, certificates of compliance, etc.) shall be collected and maintained by the subcontractor and submitted for URA approval at least sixty (60) days before acceptance testing.

(CDRL No. 14 - Parts Qualification Plan)

3.2.4 Processes and Methods

As required by the URA approved Quality Assurance Plan, the subcontractor shall develop, maintain, and follow written procedures for all special fabrication processes required to satisfy the provisions of the NDT specifications. Such processes shall include, but are not limited to: welding, brazing, heat treating, non-destructive examination, chemical machining, cleaning and packaging, leak checking, and pressure testing. Procedures shall conform to the recommended practices of the applicable code governing the design of the component (ASME, AWS, etc.). These procedures shall be submitted to URA for approval at least sixty (60) days prior to use.

(CDRL No. 15 - Process Specifications)

3.2.5 Testing

The subcontractor shall develop a fabrication test plan (FTP) defining product quality verification testing to be performed during fabrication and assembly of the NDT components including all field assembly tasks. Tests required by the NDT specifications and the subcontractor's quality assurance program shall be included. The FTP shall be submitted for approval by URA at least sixty (60) days prior to use.

For each test the FTP shall include the following:

a. Description of objectives and definition of criteria,

b. Identification of equipment and supplies required,

c. Detailed test procedure,

d. Form(s) for reporting the test results.

Test results shall be reported to URA. For each test for which a witness point has been identified in Section 3.2.4, above, or Section 3.2.10, below, the results shall be reported to URA within five (5) days of completion of the test.

(**CDRL No. 17** - Fabrication Test Plan)

(CDRL No. **18** - Witnessed Fabrication Test Results)

The results of all fabrication tests, including witnessed tests, shall be compiled by the subcontractor in a Fabrication Test Report which shall be submitted to URA within thirty (30) days after completion of the last test. **(Note that this does not include acceptance tests).** URA reserves the right to witness any testing conducted at any subcontractor facility, at any of its vendors' facilities, or in the field.

(CDRL No. **19** - Fabrication Test Report)

3.2.6 Spares

Spare parts sufficient for two years of operation shall be identified. All spare parts shall be listed in the spare parts list. URA reserves the option to purchase any subset of the spare parts list.

(CDRL No. 20 - Spare Parts List)

3.2.7 Reserved

3.2.8 Installation

The prototype set of two NDT shall be installed by the subcontractor in URA-supplied facilities near Waxahachie, Texas. The installation shall be conducted in accordance with the approved program management plan and the applicable codes, standards, and specifications set forth in the NDT specifications and in this Statement of Work. This SOW considers installation tasks to include fabrication tasks accomplished in the field.

The following witness points shall be included in the subcontractor's installation schedule. URA shall be notified at least five (5) working days in advance of each witness point.

a. Completion of major subsystems and/or modules.

b. Functional tests and leak checks.

3.2.9 Maintenance Manual

Prior to installation of the prototype set of two NDT, a maintenance manual shall be provided. The maintenance manual shall comply with the safety requirements for use of DANGER, WARNING, CAUTION, and NOTE notations. In addition, a NOTE shall be used to explain critical steps where human assembly errors could cause a failure. The manual shall include a list of all spares and equipment required for maintenance.

(CDRL No. 41- Maintenance Manual)

3.3 RESERVED

3.4 RESERVED

3.5 PROGRAM MANAGEMENT

The subcontractor shall manage the design, development, test, fabrication, and installation tasks defined by this SOW in accordance with the NDT Program Management Plan referenced in Section 2.3, above. The subcontractor shall provide a single point of contact for all data, information, and policy communications to and from the URA subcontract administrator. The language of communication for all activities associated with the NDT shall be English.

The subcontractor shall describe the structure of their organization which will contribute to the performance of this contract, and shall identify responsible personnel (by position and by name).

(CDRL No. 36- Contractor Organization)

3.5.1 Contract Work Breakdown Structure (CWBS)

The subcontractor shall deliver a CWBS. The subcontractor shall identify within the CWBS all significant subcontractual elements and tasks. The subcontractor shall not change the CWBS or associated definitions for any contractual elements or tasks at level three or above without URA approval. Changes at lower levels may be made by the subcontractor as deemed necessary. Schedules shall be keyed to the CWBS and the SOW deliverables.

(CDRL No. 35 - Contract Work Breakdown Structure)

3.5.2 Lower Tier Subcontract Management

The subcontractor shall provide monthly schedule, supportability, and technical progress information about lower tier subcontracts to URA. The subcontractor shall implement program planning and control necessary to accomplish the lower tier subcontract effort. The subcontractor shall inform the URA subcontract administrator of, and invite URA personnel to, all lower tier subcontract technical interchange meetings, design reviews, test reviews, and program management reviews.

(CDRL No. 37- Lower Tier Subcontract Data)

3.5.3 Program Schedules

The subcontractor shall develop and maintain a master schedule of milestones and events planned to occur throughout the duration of the contract. The subcontractor shall extend the master schedule to the lowest CWBS level necessary for management control. The schedule, as a minimum to level 3, shall be updated monthly and reported to URA.

(**CDRL No. 27**- Program Schedules)

3.5.4 Configuration Management (CM) and Control

Configuration control shall be performed in accordance with the CM section of the subcontractor's program management plan as approved by URA.

3.5.5 System Safety

3.5.5.1 Safety Analysis

The subcontractor design process shall ensure that safety is an inherent part of system design. The subcontractor shall identify potential risk factors associated with system designs and human operations including detailed hazard analyses. The subcontractor shall perform a hazard analysis that comprehensively addresses safety issues according to Section 2.2.d, using Section 2.3.a as a guide, including but not limited to: Industrial safety, fire protection, environment, and industrial hygiene. Risk assessments shall be performed and mitigation methods applied until all identified risks are within the limits defined in the Technical Specification.

(**CDRL No. 28**- Safety Analysis)

3.5.5.2 Material Safety Data Sheets (MSDS)

The subcontractor shall prepare and deliver all current material safety data sheets for any hazardous material in the delivered end item. The MSDS shall consist of the following sections:

a. Identification: The company name, address and emergency phone number of the material manufacturer.

b. Hazardous ingredients: The material's hazardous components and their common names, worker exposure limits to the substance, and other recommended limits.

c. Physical and chemical characteristics: Listings of known physical and chemical characteristics of the material, such as: boiling point, vapor pressure, vapor density, melting point, evaporation rate, appearance, odor, and color under normal conditions.

d. Physical hazards: Physical hazards and recommended methods for handling the hazards.

e. Reactivity: Stability of the material, and identification of substances that when mixed with the material cause it to become unstable.

f. Health hazards: Ways the material could enter and affect the body of a person who has been exposed.

g. Precautions for safe handling and use: Procedures for safely handling the material, and procedures to follow in case of a spill or leak of the material. Proper storage procedures for the material shall be included in this section.

h. Control measures: Methods and equipment to be used when in contact with or exposed to the material.

(**CDRL No. 29**– Material Safety Data Sheets)

3.5.5.3 On-Site Activities

All subcontractor personnel shall comply with Section 2.1.e, SSC Laboratory Environment, Safety and Health Manual requirements when performing activities on an SSCL site. All related subcontractor plans and procedures shall ensure that the subcontractor's employees receive appropriate training prior to performing on-site activities. Training shall be coordinated with the SSCL System Safety Project Office.

3.6 QUALITY ASSURANCE

The subcontractor shall establish and maintain a quality assurance program. Approval of the quality assurance section of the program management plan constitutes URA concurrence with the subcontractor's approach to satisfying program quality assurance requirements.

3.7 SSCL NUMBERING SYSTEM

Document identification will be in accordance with the document numbering system established by the SSCL for those documents delivered to the SSCL. The procedure for use of the document numbering system will be furnished to the subcontractor by SSCL at the time of subcontract award.

3.8 UNITS OF MEASURE

The subcontractor shall use either the S.I. or English system for design documentation, drawings, tooling, materials, and all other applications where appropriate. However, interfaces between the NDT and SSCL equipment shall be in English units. (piping, wiring, fasteners, etc.) **The system selected by the subcontractor shall remain consistent throughout the proposal and for all work,** with the measurement given in parentheses in the alternate system of notation for all primary measurements.

3.9 RESERVED

3.10 MANAGEMENT REVIEWS AND TECHNICAL MEETINGS

3.10.1 Technical Interchange Meetings (TIM)

The subcontractor shall conduct technical interchange meetings to coordinate system requirements and schedules and to discuss mutual interest topics related to the SOW. Such meetings may be formal or informal in nature as dictated by the topics to be discussed and may or may not require formal minutes. Timing and location of meetings shall be as required and agreed to by URA and the subcontractor.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.10.2 Technical Reviews

Design reviews will be co-chaired by designated personnel from URA and the subcontractor. The subcontractor shall be responsible for the following: development, preparation and submission of agendas; engineering data required for technical evaluation; presentation materials; maintenance of the minutes and action items resulting from the reviews. Engineering data to be discussed as part of the scheduled review shall be transmitted to URA in accordance with Section F of the subcontract. Approval of the review constitutes acceptance of the milestone and authorization to proceed.

Reviews shall be held at the subcontractor's facility on URA-approved dates in the subcontractor's master schedule. The subcontractor shall prepare and deliver meeting minutes and action items for URA approval within five (5) working days after a review.

(CDRL No. 1 - Meeting Agendas)
(CDRL No. 2 - Meeting Minutes)

3.11 TECHNICAL REPORTS

The subcontractor shall provide a monthly written technical progress report in subcontractor format. The report shall include the following sections and data, organized by task:

a. Summary of work performed, including milestone chart(s), showing work accomplished during the month and work remaining to be completed.

b. Discussion of problems encountered during the previous month and proposed method of solution.

c. Planning data for future work.

d. Any other information deemed appropriate.

e. Additional data requested by URA.

(CDRL No. 30- Monthly Report)

3.12 COST REPORTS

The subcontractor shall provide monthly cost status reports to URA. The cost information shall evaluate cost performance against the CWBS and contractual deliverables.

(CDRL No. 31- Cost Reports)

4.0 RESERVED

5.0 CUSTOMER FURNISHED PROPERTY/SERVICES

TBD

ANNEX 1 TO ATTACHMENT J-1

CONTRACT DATA REQUIREMENTS LIST

NITROGEN DUMP TANKS
STATEMENT OF WORK

CDRL	TITLE	SOW REF	DELIVERY	APPROVAL
1	Meeting Agendas	3.1.2.1,.2 3.10.1,.2	As Req'd	No
2	Meeting Minutes	3.1.2.1,.2, 3.10.1,.2	As Req'd	Yes
5	Drawings, Level 2	3.1.2.2	30D CDR	Yes
7	Reliability Analysis	3.1.2.2 3.1.3.1	CDR	Yes
8	Failure Modes Analysis	3.1.2.2 3.1.3.2	CDR	Yes
10	Maintainability Program Plan	3.1.2.2	CDR	Yes
11	Product Specifications	3.1.2.2 3.1.4.1	30D CDR	Yes
12	As Built Drawings	3.1.4.2	As Req'd	Yes
14	Parts Qualification Plan	3.2.3	60D AT	Yes
15	Process Specifications	3.1.4.1 3.2.4	CDR 60D	Yes
17	Fabrication Test Plan	3.2.5	As Req'd	Yes
18	Witnessed Fabrication Test Results	3.2.5	FT 5D	No
19	Fabrication Test Report	3.2.5	As Req'd	No
20	Spare Parts List	3.2.6	60D Install	No
21	Material Specifications	3.1.4.1	CDR 60D	Yes
23	Acceptance Test Plan	3.1.2.2	CDR	Yes

27	Program Schedules	3.2.1 3.5.3	Monthly	No
28	Safety Analysis	3.5.5.1	30D CDR	Yes
29	Material Safety Data Sheets	3.5.5.2	30D CDR	Yes
30	Monthly Report	3.11	Monthly	No
31	Cost Reports	3.12	Monthly	No
32	Interface Control Documents	3.1.4.3	As Req'd	Yes
35	Contract Work Breakdown Structure	3.5.1	CA 30D	Yes
36	Contractor Organization	3.5	CA 30D	No
37	Lower Tier Subcontract Data	3.5.2	Monthly	No
41	Maintenance Manual	3.2.9	120D Install	Yes

Delivery Examples- CA 30D = 30 days after Contract Award, 30D CDR = 30 days before CDR

CDRL 1 - Meeting Agenda

Meeting agenda notifications shall include as a minimum:

a. location, dates, and times,
b. name(s) of meeting chairperson(s) or person calling the meeting,
c. schedule of items to be discussed and presenters,
b. and action assignments and status form previous meeting.

CDRL 2 - Meeting Minutes

Meeting Minutes shall include, but are not limited to:

a. names of all meeting participants,
b. discussion of each pertinent agenda item,
c. recommendations provided by both subcontractor and URA,
d. and action assignments identified with schedules and responsibility for accomplishment.

CDRL 5 - Drawings, Level 2

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

CDRL 7 - Reliability Analysis

Record the reliability requirements for the end item, major subsystems and critical components to include, but not limited to:

a. possible failure modes,
b. probability of occurrence of each failure mode,
c. times during operation the failure mode can occur,
d. classification of the failure mode (critical, major, minor),
e. end item reliability when the failure occurs,
f. and end item reliability when the failure does not occur.

CDRL 8 - Failure Modes Analysis

Reference SOW paragraph 3.1.3.2

CDRL 10 - Maintainability Program Plan

Plan describes the subcontractor's maintainability program, how it will be conducted and the controls and monitoring provisions, if any, levied on suppliers and vendors. It describes the techniques and tasks to be performed and their integration and development in conjunction with other related activities.

<u>CDRL 11 - Product Specifications</u>

Reference MIL-STD-490B, Specification Practices

<u>CDRL 12 - As Built Drawings</u>

Reference DOD-STD-1000B, Drawings, Engineering and Associated Lists

<u>CDRL 14 - Parts Qualification Plan</u>

The plan shall contain, but is not limited to ,the following

a. the inspections and tests necessary to qualify the part,

b. the justification for using generic qualification, reduced testing, or limited usage procedures for qualifying,

c. the manner in which samples will be chosen, the period they will be chosen, and the elapsed time between qualification inspections,

d. the description of the test procedures; electrical, environmental, and operational used in qualifying the part,

e. and the data to be recorded.

<u>CDRL 15 - Process Specifications</u>

Reference MIL-STD-490B, Specification Practices

<u>CDRL 17 - Fabrication Test Plan</u>

Reference SOW paragraph 3.2.5

<u>CDRL 18 - Witnessed Fabrication Test Results</u>

Reference SOW paragraph 3.2.5

CDRL 19 - Fabrication Test Report

Reference SOW paragraph 3.2.5

CDRL 20 - Spare Parts List

Reference SOW paragraph 3.2.6

CDRL 21 - Material Specifications

Reference MIL-STD-490B, Specification Practices

CDRL 23 - Acceptance Test Plan

A. Overview. Includes flow diagrams, milestones, personnel participation, and safety requirements:

1. Flow diagrams. A functional description of the acceptance test program using a block diagram portrayal of the functions that must be met to satisfy the total acceptance program,
2. Milestones. Identifies the start and expected completion dates of each test to be performed,
3. Participation. Identifies the contractor and URA participation roles and responsibilities,
4. Safety. Identify and state any safety measures or guidelines to be observed during testing.

B. Master Test List. List all tests to be accomplished in the order they are to be performed. Separate listings for each location shall be provided. Listing shall include:

1. Location where the test is to be performed,
2. Number for each piece of equipment or item test will be performed,
3. Name and brief description of test to be performed,
4. Number of cycles the test will be performed and selected parameters to be observed.

C. Equipment List. The list shall include all equipment to be used in the test. The listing shall include the following:

1. All test equipment by description, nomenclature, serial number;
2. All support equipment by description, nomenclature and serial number;

3. All special test equipment required to be designed or constructed for use on the program by description, nomenclature, and date required.

D. Validation. An overview of the procedures that will be used to validate the test results.

CDRL 27 - Program Schedules

Reference SOW paragraph 3.2.1 and 3.5.3

CDRL 28 - Safety Analysis

The purpose of this plan is to provide a basis of understanding between the subcontractor and URA to ensure that adequate consideration is given to safety during all phases of the program.

Plan details the tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate or control hazards throughout the system life cycle.

CDRL 29 - Material Safety Data Sheets

Reference SOW paragraph 3.5.5.2

CDRL 30 - Monthly Report

Reference SOW paragraph 3.11

CDRL 31 - Cost Reports

Reference SOW paragraph 3.12

CDRL 32 - Interface Control Documents

Documents shall be prepared to control the interfaces between two or more system segments and to provide a common data reference for the segments where the control of a single interface rests within the design tasks delineated within this SOW and the associated specifications. Documents shall specify in subparagraphs as appropriate, in quantitative

terms with tolerances, the mechanical, electrical, and functional relationships of the interfacing system segments, to the level of detail necessary to permit detail design.

CDRL 35 - Contract Work Breakdown Structure

Reference SOW paragraph 3.5.1.

CDRL 36 - Contractor Organization

Reference SOW paragraph 3.5

CDRL 37 - Lower Tier Subcontract Data

Reference SOW paragraph 3.5.2

CDRL 40 - Training Syllabus

Training Syllabus shall include as a minimum:

a. Classroom and practical application time,

b. Time allocated for each topic of instruction,

c. Scheduled order of presentation,

d. Separate schedule listing for classrooms, training equipment, and laboratory use,

e. Resource requirements list,

f. and Curriculum Outline providing detailed training data for each lesson.

CDRL 41 - Maintenance Manual

These manuals shall include detailed machine functions, basic diagnostic operations, basic operational procedures, operation of maintenance switches and associated test equipment, recommendations for preventative maintenance schedules, and suggested maintenance routines. When a commercial manual is available and considered adequate, the subcontractor may recommend the manual and submit a copy for approval.

Date:04/15/94 10:45 AM
Revision: 0

DRAFT 4

TECHNICAL SPECIFICATION

of the

Tunnel Warm Lines (TWL)

designated as the

Warmup Cooldown Header (WCH)

and the

Lead Cooling Header (LCH)

part of the

Sector Tunnel System (STS)

for the

Collider Main Ring and

High-Energy Booster (HEB) Ring

submitted by the

Superconducting Super Collider Laboratory (SSCL)

Accelerator Systems Division / Cryogenics Systems Department

Prepared by:

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ASD/ Cryogenics

Table of Contents

1.0 Scope.. 3
2.0 Applicable Documents... 4
    2.1 Industry and Society Documents.. 4
    2.2 SSCL Documents 5
3.0 Requirements... 6
3.1 Descriptions 6
    3.1.1 *Collider Warmup Cooldown Header WCH* 6
    3.1.2 Collider Lead Cooling Header LCH... 7
    3.1.3 HEB Warmup Cooldown Header WCH 7
    3.1.4 HEB Lead Cooling Header LCH... 7
3.2 Design requirements.. 8
    3.2.1 General specifications and references : 8
3.2.2 Table 1:.. 8
4.0 Quality Assurance Requirements 8
5.0 Preparation for Delivery 8
6.0 Notes.. 8
Installation Subcontractor Requirements.. 9

Tunnel Warm Lines (TWL)

Warmup Cooldown Header (WCH)
Lead Cooling Header (LCH)

1.0 Scope

The Warmup Cooldown Header (WCH) and the Lead Cooling Header (LCH) are warm gas helium systems that are installed within the tunnel and shaft areas. This specification details the design, fabrication, installation, inspection and testing requirements for these systems. The WCH and the LCH are intregal parts of the collider and high energy booster (HEB) underground cryogenic equipment and will be used to convey helium gas within the tunnels.

2.0 Applicable Documents

The following documents of the exact issue shown form a part of this specification document to the extent specified herein. If a conflict arises between the documents referenced below and the contents of this specification, the latter shall prevail.

2.1 Industry and Society Documents

American Society of Mechanical Engineers (ASME)

1. B31.3-1987: Chemical Plant and Petroleum Refinery Piping

American Society for Testing and Materials (ASTM)

1. A 312: Stainless Steel Pipe
2. A 380-88: Standard Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems
3. E 493-73(80), E 498-73(80), E 499-73(80): Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector...(various modes)

Compressed Gas Association (CGA)

1. CGA P-12: Safe Handling of Cryogenic Liquids
2. CGA P-14: Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres
3. CGA S-1.3: Pressure Relief Device Standards—Part 3: Compressed Gas Storage Containers

Institute of Electrical and Electronics Engineers (IEEE)
Specific items to be listed by subcontractor during design stage.

National Institute of Standards and Technology (NIST—formerly National Bureau of Standards [NBS])
NIST Technical Note 1334: Thermophysical Properties of Helium-4 from 0.8 to 1500 K with Pressures to 2000 MPa

Underwriters' Laboratories, Inc. (UL)
Specific items to be listed by subcontractor during design stage.

American Welding Society (AWS)
AWS D10.4 : Recommended Practices for Welding Austinitic Chromium - Nickel Stainless Steel Piping and Tubing.

2.2 SSCL Documents

The following documents form a part of this specification requirements:

Dwg Number	Description
TBD	**TBD**
TBD	**TBD**

SSCL Standard P40-000175 : Preparation for Delivery

The following documents provide additional information and background but are not part of the requirements of this specification:

1. "SSC Cryogenics System," *Site-Specific Conceptual Design* (SSC-SR-1056). Dallas, Texas: SSC Laboratory, July, 1990.
2. Than, R., S. Abramovich and V. Ganni. "The SSCL Cryogenic System Design and the Operating Modes," SSCL Cryo Note 92-12, October 1992.

2.3 Source of Documents

Any difficulty in obtaining the applicable documents should be referred to the SSCL Subcontract Administrator. Documents may be obtained from the following:

2.3.1 Industry and Society Documents
Copies can be obtained from the appropriate professional organization referenced. Reference copies of technical society and association documents are generally available in libraries.

2.3.2 SSCL Documents
Frank Rydeen
Deputy Chief Engineer
2550 Beckleymeade Avenue
Dallas, TX 75237

3.0 Requirements

3.1 Descriptions

The Warmup Cooldown Header (WCH) and the Lead Cooling Header (LCH) are warm gas helium distribution systems that are installed within the tunnel and shaft areas of the collider and high energy booster (HEB) and will be used to convey helium gas within the tunnels. They consists of two parallel pipes that are mounted to the tunnel walls in such a position that branch lines can be then connected to the appropreate spool piece ports. Both headers consist of uninsulated stainless steel pipe and fittings.

The collider will contain one WCH piping system and one LCH piping system per refrigeration Sector (total of ten per the collider). The HEB will contain one WCH piping system and one LCH piping system per refrigeration Sector (total of two systems).

Refer to Figure (TBD) Flow Diagram and Figure (TBD) Branch Isometric drawings for details of a typical (N-15) Sector system.

The WCH provides a return to the helium refrigerator compressor of gas resulting from warmup or cooldown operations(utility modes) performed on the magnet rings. The WCH also serves as a circulation conduit during Section maintenance operations(utility modes). After string shutdown, the magnets within one isolated Section of one ring can be warmed and prepared for further maintenance operations without affecting the magnet's standby mode in the remainder of the string. During utility mode, the pressure of this isolated Section header can be raised to allow efficient operation of curculation devices(blowers). The warmed gas stream from these blowers will flow through electric gas heaters, circulate through the desired magnet(s) and return to the isolated Section header.

The LCH provides a return to the helium refrigerator compressor of gas from the power leads, bypass leads and corrector lead systems at each SPXX spool piece located within the magnet rings. A reduced size branch connection, with an isolation valve and header piping, is installed at each spool. The main header is maintained at a constant low pressure for use by any string under operation. If maintenance is performed on one string Section of magnets, the branch isolation valves are closed to the spools in that Section. Therefore, the remaining string magnets can continue to operate in standby mode.

3.1.1 Collider Warmup Cooldown Header WCH

This system consists of a main header running from an even-number shaft to the next even-number shaft within the collider tunnel. An isolation valve shall be located in this main header at each SPRI(recooler wth isolation) spool piece location. A branch connection with disconnects shall be located at each V1 cooldown valve which are mounted on SPRx (recooler) spool pieces located along the tunnel. In addition, two branches, with isolation valves, for a portable warmup circulator (SSCL-supplied) shall be located along each service section, (between SPRI spool pieces). At both ends of the main header there shall be a full ported on/off control valve that connects to the next sector piping.
At the middle of the main header there shall be two full ported on/off control valves at the utility shaft location for isolation of each sector half. Between these on/off control valves there shall be a tee leading to a vertical run within the utility shaft.
The vertical shaft run shall be connected to a modulating control valve and then to the compressor supply at a surface interface point. The length of this vertical run will be dependent on individual shaft dimensions.
Pressure and temperature indicators and relief valves shall be located between pairs of isolation and control valves.

3.1.2 Collider Lead Cooling Header LCH

This system consists of a main header running from each even-number shaft to the next even-number shaft within the collider tunnel. An isolation valve shall be located in this main header at each SPRI(recooler wth isolation) spool piece location. A single branch connection shall be located at each SPxx spool piece location along the tunnel. Branch header connections shall be made to individual V4 (SPRF & SPRE only),V5, V6, and V7 valves which are mounted on each SPxx spool piece.
At both ends of the main header there shall be a full ported on/off control valve that connects to the next sector piping. At the middle of the main header there shall be two full ported on/off control valves at the utility shaft location for isolation of each sector half. Between these control valves there shall be a tee leading to a vertical run within the utility shaft.
The vertical shaft run shall be connected to a modulating control valve and then to the compressor supply at a surface interface point. The length of this vertical run will be dependent on individual shaft dimensions.
Pressure and temperature indicators and relief valves shall be located between pairs of isolation and control valves.

3.1.3 HEB Warmup Cooldown Header WCH

This system shall consist of a main header running from H40 shaft to H80 shaft within the HEB tunnel. An isolation valve shall be located in this main header at each SPRI(recooler wth isolation) spool piece location. A branch connection with disconnects shall be located at each V1 cooldown valve which are mounted on SPRx (recooler) spool pieces located along the tunnel. In addition, two branches, with isolation valves, for a portable warmup circulator (SSCL-supplied) shall be located along each service section, (between SPRI spool pieces). At both ends of the main header there shall be a full ported on/off control valve that connects to the next sector piping.
At the middle of the main header there shall be two full ported on/off control valves at the utility shaft location for isolation of each sector half. Between these on/off control valves there shall be a tee leading to a vertical run within the utility shaft.
The vertical shaft run shall be connected to a modulating control valve and then to the compressor supply at a surface interface point. The length of this vertical run will be dependent on individual shaft dimensions.
Pressure and temperature indicators and relief valves shall be located between pairs of isolation and control valves.

3.1.4 HEB Lead Cooling Header LCH

This system shall consist of a main header running from H40 shaft to H80 shaft within the HEB tunnel. A single branch connection with isolation valving shall be located at each SPxx spool piece location along the tunnel. Branch connections shall be made to individual V4 (SPRF & SPRE only),V5, V6, and V7 lead cooling valves which are mounted on each SPxx spool piece.
At both ends of the main header there shall be a full ported on/off control valve that connects to the next sector piping. At the middle of the main header there shall be two full ported on/off control valves at the utility shaft location for isolation of each sector half. Between these control valves there shall be a tee leading to a vertical run within the utility shaft.
The vertical shaft run shall be connected to a modulating control valve and then to the compressor supply at a surface interface point. The length of this vertical run will be dependent on individual shaft dimensions.
Pressure and temperature indicators and relief valves shall be located between pairs of isolation and control valves.

3.2 Design requirements

3.2.1 General specifications and references :

- Branch spool concept drawings, Fig **TBD**, shall be used to develop detailed design drawings.
- *Piping shall be designed, fabricated, inspected, installed and tested per* ASME Standard B31.3, "Chemical Plant and Petroleum Refinery Piping".
- Pipe shall conform to ASTM A312 "Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes" and material shall be type 304 stainless steel.
- Piping shall be cleaned per ASTM A 380-88.
- Piping shall be designed for a maximum allowable working pressure (MAWP) of 300 psi (20 bar)at a temperature of 300K and a minimum, short duration, temperature of -(minus) 452 deg F (4K) during maintenance operations.
- Minimum pipe wall thickness shall be Schedule 10s.
- The design of piping supports and expansion devices shall be per current industry standards and shall be based on a flexibility analysis as required by ANSI B31.3 and the worst case operating conditions as listed in Table 1 for each piping system.
- Safety relief devices shall be ASME certified and flow sized for worst case conditions per CGA S-1.3.
- All joints shall be welded and leak checked with a helium MSLD for a maximum leak rate of 10^-9 mbar liter/sec per ASTM #....**(TBD)**.
- The completed piping system shall be leak checked per ASTM #.........**(TBD)**.
- Valving shall be designed for 20 bar helium gas service at 80K and contain limit switches for open / closed position indication. The valve bodies will recieve cold 4K helium gas flow for a short **(TBD)** duration during maintenance operations. Valve actuators shall be supplied for all header valves and of the type shown on the P&ID Drawing #.**(TBD)**. Selection and sizing of valves and actuators shall be subject to SSCL review and approval.

3.2.2 Table 1:

Tunnel Warm Lines (Main Header data only)	Collider WCH	Collider LCH	HEB WCH	HEB LCH
Nominal Line Size NPS, inches	4	4	4	4
Approximate Length of Header, meters	8190	8190	5400	5400
Number of Headers per Tunnel	10	10	2	2
Approx. Number of Branches per Header	51	186	**TBD**	**TBD**
Design Flow, g/s helium gas at 300K	200	36	200	36
Design Pressure, bar	20	20	20	20
Utility Mode (Normal Operation) Pressure, bar	6	1.2	6	1.2
Utility Mode (Normal Operation) Temp., K	ambient	ambient	ambient	ambient
Maintenance Mode (Short Duration) Pressure, bar	10		10	
Maintenance Mode (Short Duration, total) Temp., K	4		4	

4.0 Quality Assurance Requirements

5.0 Preparation for Delivery

Piping elements are to be protected during shipment and storage at Level C standard as per SSCL Standard P40-000175 : Preparation for Delivery.

6.0 Notes

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INSTALLATION REQUIREMENTS

for
SSC Underground Cryogenic Facilities

Document Control Number AHA 1110003

submitted by the
Superconducting Super Collider Laboratory (SSCL)
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Table of Contents

1.0 Introduction 3
2.0 Subcontractor Responsibilities 4
2.1 General 4
2.2 Installation Activities 4
2.3 Engineering Services 4
3.0 Summary of Subcontractor Installation Tasks 5
3.1 Shaft transfer line (STL) and Adit transfer line (ATL) 5
3.2 Cold compressor box (CCB), Tunnel distribution box (TDB), Nitrogen distribution box (NDB) 5
3.3 Nitrogen dump tanks (NDT) 5
3.4 Collider Bypasses, HEB Bypasses 5
3.5 Warmup Cooldown Header (WCH), Lead Cooling Header (LCH) 5
4.0 Definition of Subcontractor Installation Tasks 6
4.1 Equipment Group A 6
4.1.1 Shaft Transfer Line (STL) 6
4.1.2 Cold Compressor Box (CCB) 6
4.1.3 Tunnel Distribution Box (TDB) 7
4.1.4 Nitrogen Distribution Box (NDB) 7
4.1.5 Adit Transfer Lines (ATL) 8
4.1.6 Nitrogen Dump Tanks 8
4.1.7 Miscellaneous Equipment (TBD): 8
4.2 Equipment Group B 9
4.2.1 Collider and HEB Cryogenic Bypasses 9
4.2.1.1 Standard Bypass Cryostat 9
4.2.1.2 Special Bypass Cryostats 9
4.2.1.3 Connection Boxes 9
4.2.1.4 Tube Sets 9
4.3 Equipment Group C 10
5.0 Appendix 11
Equipment Group A 11
Equipment Group B 11
Equipment Group C 11

1.0 Introduction

This document (a) describes the underground cryogenic equipment for the collider and the high energy booster (HEB) and (b) defines tasks related to this equipment. These tasks shall be performed by the organization, hereafter referred to as the installation subcontractor or subcontractor, who is responsible for installing the technical systems of the SSC. Brief descriptions of the installation tasks are contained in the body of this document. More detailed descriptions of the equipment are contained in the appendices. Material contained in this document will be updated as the project proceeds and further information becomes available, and *may be revised to reflect any design changes.*

Originating at the odd number utility shaft locations, the underground cryogenic equipment connects to the process piping from the surface refrigeration systems (SRS) thereby completing the cryogenic process piping into the tunnel and through the magnet strings. At eleven (11) sites (N25, N35, N45, N55; S15, S25, S35, S45, S55, H20, H60) the underground cryogenic equipment will convey the cryogens from an existing surface distribution box (SDB), down the utility shaft, through the superconducting magnets in the tunnels and finally returning to the SDB.

A special case will be at a twelfth site (N15) where, in addition to the normal underground cryogenic equipment, a number of surface transfer lines and a single surface distribution box (SDB) shall be installed by the subcontractor. In this case, the installation interface will be at existing N15 refrigeration devices. Work at the N15 site will be the prime tunnel installation activity and an early completion at this site is required for a successful Loop Test in which a preliminary magnet system will be placed in operation. This Loop Test activity requires a special effort for the installation of the underground equipment and this work will be described in detail in other documents.

2.0 Subcontractor Responsibilities

2.1 General

The subcontractor shall supply all services required for the installation work including all manpower, tools, resources and material handling equipment.

2.2 Installation Activities

The subcontractor shall perform the following installation work:

- Prepare written procedures for the installation of each piece of equipment.
- Prepare, assemble and erect all supports and hangers as required.
- Transport equipment from storage.
- Rig and lower into tunnel.
- Position equipment in tunnel.
- Align components as necessary and anchor in place.
- Complete all equipment connections including piping, instrumentation and electrical.
- Pressure test, leak test, insulate and final finish as required.

2.3 Engineering Services

In some instances the subcontractor shall provide engineering and other services related to the installation such as the following:

- Design of hardware such as piping, expansion joints, anchors, hangers, and other supports.
- Design of weld joints and weld procedures.
- Development of specifications for materials and processes.
- Development of procedures for installation, assembly, fabrication, examination, and testing.
- Procurement and management of vendor items such as piping, fittings, valves, hangers and supports.

3.0 Summary of Subcontractor Installation Tasks

At each sector, except the N15 site, the boundary of the surface equipment is at the surface distribution box (SDB). The N15 site surface boundary is at the existing refrigeration devices. The underground cryogenic equipment installation tasks consist of the following:

3.1 Shaft transfer line (STL) and Adit transfer line (ATL)

- Design and procure supports and hangers
- Assemble, install supports and hangers
- Install and align modules
- Make field connections (piping, MLI insulation, vacuum jacket, etc.)
- Perform pressure and leak tests

3.2 Cold compressor box (CCB), Tunnel distribution box (TDB), Nitrogen distribution box (NDB)

- Install and align boxes
- Make field connections (piping, MLI insulation, vacuum jacket, electrical wiring, utilities, etc.)
- Perform pressure and leak tests
- Perform functional test of valves, instruments, etc.

3.3 Nitrogen dump tanks (NDT)

- Design and procure piping
- Install and align tanks
- Make field connections (piping, utilities, instrumentation, etc.)
- Perform pressure and leak tests
- Perform functional test of valves, instruments, etc.

3.4 Collider Bypasses, HEB Bypasses

- Procure supports and hangers
- Assemble and install supports and hangers
- Install and align modules
- Make field connections (piping, MLI insulation, vacuum jacket, superconducting bus, etc.)
- Perform pressure and leak tests

3.5 Warmup Cooldown Header (WCH), Lead Cooling Header (LCH)

- Design and procure piping
- Install piping, branch spools, and hangers
- Make field connections (utilities: electrical, pneumatic, instrumentation, etc.)
- Perform pressure and leak tests
- Perform functional test of valves, instruments, etc.

4.0 Definition of Subcontractor Installation Tasks

4.1 Equipment Group A

Shaft transfer line (STL) and Adit transfer line (ATL)
Cold compressor box (CCB), Tunnel distribution box (TDB), Nitrogen distribution box (NDB)
Nitrogen dump tanks (NDT)
Miscellaneous equipment

Refer to the Appendix for full description.

4.1.1 Shaft Transfer Line (STL)

At each site, the shaft transfer line shall be connected to the surface distribution box. This line consists of seven stainless steel tubes enclosed in a common vacuum jacket (24 in, schedule 10 carbon steel pipe). Each transfer line is to be built in basic construction units (straight module and elbow piece) and assembled on-site. The maximum length of the straight module is 40 feet (12 m). A cross section of the shaft transfer line is presented in Figure **TBD**.

The subcontractor shall perform the following tasks:

- Procure and install the external suspension system (supports, hangers, anchors, etc.) The placement of these devices will be at the shaft surface collar and shaft floor.
- Install and align the STL modules in the shaft by mounting to the external suspension system.
- Make interconnect field connections between modules and at equipment interfaces:
  The shaft transfer line construction units (straight modules and elbow pieces) shall be field-connected by the subcontractor. The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding.
- Perform pressure and leak tests

4.1.2 Cold Compressor Box (CCB)

The cold compressor box is a vertical, vacuum vessel, approximately 12 feet in diameter and 16 feet tall. The cold compressor is in a separate housing that is connected to the cold compressor box through a pair of cryogenic "U" tubes. These "U" tubes are vacuum jacketed pipes with expansion joints and bayonet connections at each end.

- The subcontractor shall perform the following tasks:

  - Install and align the cold compressor box and cold compressor
  - Make interconnection between the cold compressor box and the cold compressor:
    The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding.
  - Install valve actuators
  - Connect utilities (electrical, pneumatic, etc.)
  - Connect instrumentation and control devices (temperature sensors, pressure sensors, etc.)
  - Perform pressure and leak tests
  - Perform functional tests of valves, actuators, instruments, etc.

4.1.3 Tunnel Distribution Box (TDB)

The tunnel distribution box is a horizontal, vacuum-insulated, cryogenic valve box, approximately 6 feet in diameter and 18 feet long, which distributes the cryogens to the four strings in a sector. The inlet of the box is connected to the shaft transfer line via the cold compressor box. The outlet of the box consists of four transfer lines leading to the feed spools.

The subcontractor shall perform the following tasks:

- Install and align the tunnel distribution box
- Connect the tunnel distribution box with the cold compressor box and with the nitrogen distribution box:
  The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding.
- Install valve actuators and their pneumatic power connection
- Connect utilities
- Connect instrumentation and control devices (temperature sensors, pressure sensors, etc.)
- Perform pressure and leak tests
- Perform functional tests of valves, instruments, etc.

4.1.4 Nitrogen Distribution Box (NDB)

The nitrogen distribution box is a horizontal, vacuum vessel, approximately 6 feet in diameter and 18 feet long, containing heat exchangers, pumps, and valving for sector nitrogen control and management.

The subcontractor shall perform the following tasks:

- Install and align nitrogen subcooler box
- Make field connections
  The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding.
- Install valve actuators
- Connect utilities
- Connect instrumentation and control devices (temperature sensors, pressure sensors, etc.)
- Perform pressure and leak tests
- Perform functional test of valves, instruments, etc.

4.1.5 Adit Transfer Lines (ATL)

The adit transfer line runs from the cold compressor box through the adit to the cryogenic alcove where it interfaces with the tunnel distribution box. This line consists of seven stainless steel tubes enclosed in a common vacuum jacket (24 in, schedule 10 carbon steel pipe). Each transfer line is to be built in basic construction units (straight module and elbow piece) and assembled on-site. The maximum length of the straight module is 40 feet (12 m). A cross section of the shaft transfer line is presented in Figure **TBD**.

The subcontractor shall perform the following tasks:

- Install the external suspension system (supports, hangers, anchors, etc.)
- Assemble, install the ATL modules in the tunnel walls
- Install and align ATL modules
- Make interconnect field connections between modules and at equipment interfaces:
  The adit transfer line construction units (straight modules and elbow pieces) shall be field-connected by the subcontractor. The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding. Sufficient clearance (4"-6") between the adit transfer line and the utility tunnel wall shall be reserved such that longitudinal cutter can be used for the removal of the interconnect section of the vacuum jacket for maintenance and repair.
- Perform pressure and leak tests

4.1.6 Nitrogen Dump Tanks

Two horizontal non-insulated nitrogen dump tanks, approximately 6 feet in diameter and 18 feet long, shall be installed in the cryogenic alcove at each site, under the tunnel distribution box and the nitrogen distribution box. The dump tanks shall be connected in parallel. The inlet of the tanks is connected to the tunnel distribution box by a section of stainless steel pipe (4" schedule 10), and the outlet is routed through the adit area and the utility shaft to the vent stack at surface level. At the surface the warm vapor nitrogen is vented to the atmosphere. The design temperature range for these tanks shall be between ambient and liquid nitrogen temperatures.

The subcontractor shall perform the following tasks:

- Design, specify and procure inlet and outlet piping and supports
- Install and align tanks and piping
- Make piping connections
- Connect utilities (electrical, pneumatic, etc.)
- Connect instrumentation and control devices (temperature sensors, pressure sensors, etc.)
- Perform pressure and leak tests
- Perform functional test of valves, instruments, etc.

4.1.7 Miscellaneous Equipment (TBD):

Liquid Nitrogen Recoolers
Piping between spools and N2 recoolers
Piping between N2 recoolers and dump tanks
Piping between N2 dump tank and vent stack
N2 Vent Stack
U Tubes between spools

4.2 Equipment Group B

Collider Cryogenic Bypass
HEB Cryogenic Bypass
Refer to Appendix B for full description.

4.2.1 Collider and HEB Cryogenic Bypasses

Cryogenic bypasses (transfer lines) route the cryogens and superconducting buses around warm equipment in the collider and HEB tunnels. The bypasses also serve various isolated superconducting magnets between warm equipment in the rings. The bypasses are composed of standard bypass cryostats, special bypass cryostats, connection boxes at the ends, and T-Boxes to serve isolated cryostats between various warm equipment in the rings.

The subcontractor shall perform the following tasks:

- Procure supports and hangers
- Assemble and install supports and hangers
- Install and align modules (standard & special bypass cryostats, connection boxes, tube sets, etc.)
- Make interconnect field connections between modules and at equipment interfaces:
  The cryogenic circuits shall be joined by use of stainless steel bellows through butt-welding and then vacuum leak checked. The thermal shield shall be soldered to the 80 K circuit tubes and covered by two MLI insulation blankets. The vacuum jacket interconnection is accomplished by use of a section of split shells (clam shells). This interconnection involves both fitting and welding.
- Make superconducting bus connections
- Perform pressure and leak tests .

4.2.1.1 Standard Bypass Cryostat
The standard bypass cryostat (BPCR) is the basic building block of the bypasses. The collider BPCR has a slot length of 15.815 m and an outer diameter of 70 mm (same as the collider dipole magnet cryostat). The HEB BPCR has a slot length of 13.171 m and an outer diameter of 70 mm (same as the HEB dipole magnet cryostat).

4.2.1.2 Special Bypass Cryostats
In addition to standard bypass cryostats, a number of shorter bypass cryostats are to be installed to match the bypass total or section lengths dictated by the lattice requirements. These special units are identical to the standard bypass cryostats in cross-section and simply differ in slot length.

4.2.1.3 Connection Boxes
Two types of connection boxes are to be installed:

a) Bypass End Boxes (BPEB), located at the ends of a bypass, allow the cryogenic and bus connections between the bypass and the magnet strings.

b) Bypass T-Boxes (BPTB) accommodate cryogenic and bus connections between the bypass and various isolated superconducting magnets. T-Boxes also contain vacuum barriers.

4.2.1.4 Tube Sets
Tube sets are needed to make the connections between the bypass connection boxes and the corresponding spools in the magnet strings. Tube sets may contain 7 or 10 lines (depending on the particular connection) in a common vacuum jacket. Each module will contain a shield and MLI.

4.3 Equipment Group C

Tunnel Warm Lines (TWL): [Warmup Cooldown Header (WCH) and Lead Cooling Header (LCH)] Refer to the Appendix for an equipment specification.

The Warmup Cooldown Header (WCH) and the Lead Cooling Header (LCH) are warm gas helium systems that are made of uninsulated, stainless steel pipe installed within the tunnel and shaft areas.

Collider WCH shall consists of a main header running from an even number shaft to the next even number shaft within the collider tunnel. There shall be a single branch connection located at each SPRx (recooler) spool piece location along the tunnel.

Collider LCH shall consist of a main header running from an even number shaft to the next even number shaft within the collider tunnel. There shall be a single branch connection with isolation valving located at each SPxx spool piece location along the tunnel.

HEB WCH shall consist of a main header running from H40 shaft to H80 shaft within the HEB tunnel.. There shall be a single branch connection located at each SPRx (recooler) spool piece location along the tunnel.

HEB LCH shall consist of a main header running from H40 shaft to H80 shaft within the HEB tunnel. There shall be a single branch connection with isolation valving located at each string SPxx spool piece location along the tunnel.

The subcontractor shall perform the following tasks:

- Produce a piping design based on the SSCL "Technical Specification of the Tunnel Warm Lines (TWL)" This specification includes requirements for flexibility and support design analysis.
- Produce formal piping system drawings for SSCL approval.
- Prepare Safety Hazard analysis.
- Provide design management services to assure the efficient installation of all warm helium piping.
- Procure and manage all piping, fittings, branch spools, valves, expansion joints, hangers and supports.
- Shop-fabricate all branch spool pieces.
- Perform pressure and leak tests on branch spool pieces at shops.
- Install piping, branch spool pieces, supports and hangers as required.
- Make electrical and instrumentation connections as required.
- Perform pressure and leak tests and functional test of valves, switches, etc.

5.0 Appendix

Equipment Group A

Shaft transfer line (STL) and Adit transfer line (ATL)
Cold compressor box (CCB), Tunnel distribution box (TDB), Nitrogen distribution box (NDB)
Nitrogen dump tanks (NDT)
Miscellaneous equipment

Equipment Group B

Collider Cryogenic Bypass
HEB Cryogenic Bypass

Equipment Group C

Technical Specification - Tunnel Warm Lines
[Warmup Cooldown Header (WCH) and Lead Cooling Header (LCH)]

SSCL /ASD/ CRYO
EQUIPMENT SPECIFICA TIONS

Date: June 1,1993, Page: 1 of 1, By: D.S. Finan

ITEM

Molecular Sieve Vessel
SSCL Drawing Number AHU 0054
Stamped: ASME Section VIII, UPVC, S/N JW 479
Vessel Material: Carbon steel
Vessel Size: 24" OD x 54" OAL
Vessel Volume: 12 cu ft
Estimated weight: 2200 # empty, 2650 # full
Pressure range: Full vacuum to 300 psig
Temperature range: -20 F to 650 F

USE

Helium gas dryer

BED DESIGN

Type adsorbent: 13X or 4A molecular sieve, 1/16" pellets
Capacity: 460 #
Press. Drop @ design flow: 1.5 psi
Dimensions: Diam = 24"nom., Ht = 36"~diam., 44" max.

PROCESS DESIGN

Helium gas flow = 20 g/s
Inlet Press. = 1.2 atm
Inlet Temp. = 90 F
Water content:
Inlet = 130 ppmv
Outlet= 1 ppmv
Design Loading: 18 # water
Adsorption time: approx. 200 hours
Total system press. drop = 2.0 psi @ 90 F

REACTIVATION

Dry Nitrogen gas flow = 50 g/s
Inlet Press = 1.2 atm
Inlet Temp. = 90 to 650 F
Press Drop = 2.9 psi ~ 90 F

Equipment Specs. Molsieve Vessel Piping System

Date: 06/16/93 D.S. Finan

PSV Pressure Safety Valve

Requirements:
300 psig set, 100 g/s min, Helium @ 300K, ASME Certification, Soft Seat

Supplier:
HALGO Inc, (214) 690 8200
11884 Greenville Ave, Suite 103, Dallas TX 75243

Anderson Greenwood # 83 MB 68-6, 3/4" x 1", .110 in^2 orifice, 988 #/hr, Brass body, $377/ea, 4wks del.

F1 Filter

Requirements:
300 psig, 2" connections, 100 g/s helium @ 300K, 50 micron element, deltaP indicator.

Supplier:
KYSER / EASTLAND, (214) 937 6111,
104 B Industrial Dr., Waxahachie TX 75165

Balston, # A15/80, 2"NPT, in line tee body
$1418, stock item (cartridges, $234/ box of three)

TI Temperature Indicator

Requirements:
Bimetal type, 3" dial, 2 1/2" stem, 1/2" male connection, 50 to 500 F range, 5 deg div.

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Taylor Bitherm, Model # BB 3102 E 047, $120/ea, 2 wks del.