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SDC
SOLENOIDAL DETECTOR NOTES

MECHANICAL UTILITIES INTEGRATION FOR THE SDC

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INTRODUCTION

The purpose of this note is to tabulate the required mechanical utilities for the SDC and identify their delivery and discharge locations to and from the detector. It is hoped that this note will assist the SDC Integration group and the SSC Lab in the following areas:

a) Identify common utilities for different subsystems
b) Utility routing in shafts, experimental hall and within the detector
c) Work Breakdown Structure (WBS), cost and schedule efforts.

In addition to the above, it is hoped that this note will serve as basis for preliminary performance spec of the mechanical utilities and it would solicit input from subsystem groups .

The mechanical utilities required in the experimental hall are:

a) Modified chilled water (CHW)
b) Chilled low conductivity water (LCW)
d) Chambers gases
f) HVAC
e) Cryogenic system
c) Butane gas

The following is a discussion of each system.

TABULATION OF THE TYPE OF UTILITIES

I. Modified Chilled Water (CHW)

The chilled water system supplies coolant to all the electronics crates in the hall and inside the detector. The supply temperature should be above the dew point, ~ 60°F and the temperature rise across the heat exchanger is about 15°F.

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The heat load distribution based on the location of the electronic crates is as follows:

	Service Location	No. of Crates	Heat Load	gpm
1)	Platform in the hall	330	660 kw	290
2)	Barrel calorimeter	128	256	113
3)	Calorimeter end caps	96	192	84
4)	Barrel muon chambers	34	68	30
5)	Forward muon (2 ends)	40	80	35
	Total CHW	**628**	**1,256 kw**	**553 gpm**

The present design calls for one CHW supply pipe and one CHW return pipe between the surface and the hall. In the experimental hall, the CHW system will be divided into the following separate cooling circuits:

a) Three circuits, one for each electronic rack platform (location #1 above)
b) One circuit for barrel calorimeter (location #2)
c) Two circuits, one for each calorimeter end cap (location #3)
d) One circuit for barrel muon chambers (location #4)
e) Two circuits for forward muon, one for each end (location #5)

That is a total of ten major circuits. Each of the circuits will be further manifolded to provide the desired flow rates to each subsystem inside the detector. A schematic of the chilled water system in the hall is shown in Fig. 1.

At present, the performance specification of the chilled water system at the point of supply and return in the hall main manifold is the following:

cooling capacity	=	1,256 kw + 25% spare
chilled water flow rate	=	553 gpm + 25% spare
min supply temperature	=	60°F
Δ T in crates	=	15°F
max supply press in hall	=	225 psi
ΔP max in the hall	=	100 psi @ 57 meters below grade
crates hex pressure rating	=	250 psi

A. CHW System Interface, WBS, Cost and Schedule

The Chilled water system interfaces with the detector subsystems on one end and the SSC Labs' facilities on the other end. The CHW system is divided into the following main sections:

1) CHW production and delivery to the hall, responsibility of the SSC Lab.
2) CHW major hall manifolding and distribution to the subsystems, responsibility of Mechanical Integration Group.
3) Subsystems manifolds and distribution to individual crates, responsibility of the subsystem groups as well as the Electrical Integration Group . Design effort of section 3 should be coordinated with the SDC ME Integration Group to insure that supply and return pipes and distribution manifold in and around the detector do not interfere with the detector assembly and disassembly operation. More detailed description of the CHW main three sections is included below to facilitate the SDC efforts in preparing WBS, costing and schedule documents.

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SSC Lab Physics Div

The SSC Lab is in charge of preparing the design, WBS, cost and schedule documents for the CHW system on the surface and down to the main distribution manifold in the hall that divide the system into nine major cooling circuits (items a through e above) That includes all surface facilities associated with the production, circulation and distribution of the CHW system (Chillers, pumps, piping in and out of the hall and instrumentation).

It is expected that the SSC Lab will have this part of the system installed prior to completing the installation of the electronic crates in the hall.

SDC Mechanical Integration Group

The SDC Mechanical Integration Group will provide the required manifolding system for the nine major cooling circuits (items a through e above) in the experimental hall. Near each subsystem crate, the ME Integration Group will provide CHW supply and return pipes for internal manifolding by the subsystem groups. The ME Integration Group must approve the routing of the flow circuits to individual crates and the location of the distribution manifolds in and around the detector. This part of the effort will appear in WBS Sect. 7.1.1

The schedule for completing this part of the CHW system depends on the completion date of the subsystems. However, an absolute installation time will be determined by the ME Integration Group and shifted up and down by the schedulers as they see fit.

SDC Subsystem Groups

The subsystem groups along with the Electrical Integration Groups will be in charge of the CHW distribution systems to and from each of the crates inside and around the detector, including manifolding, instrumentation and control systems.

Placing the interface at this distribution level gives the subsystem groups the freedom to determine the number and type (parallel/series) of cooling circuits, location of isolation and drainage valves and spec the cooling control system to adjust flow rates and distribution during operation and service.

The ME Integration Group will provide support service for the design and routing of the distribution circuits as needed

The time required to install the individual cooling circuits should be included in the subsystem installation time.

II. Chilled Low Conductivity Water (LCW)

Chilled low conductivity water (LCW) at about 65 °F is needed in the hall to cool the muon toroids' coils and perhaps some power supplies. The LCW temperature at the return manifold is about 85°F, or 20°FΔT across the coils is considered acceptable.

A. LCW Major Cooling Circuits Specifications

The heat load of the iron toroid coils is 99.2% cooled by LCW and 0.8% by the HVAC circulation system inside the detector. The breakdown of the LCW cooling load is:

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Service Location	Heat Load	Flow Rate
1) Barrel Muon Toroids	1,725 kw	574 gpm
2) Near Toroid End Caps	531 kw	176 gpm
3) Far Toroid End Caps	280 kw	93 gpm

As shown in Fig. 2, the LCW cooling circuit in the hall consists of the following main sections:

1) Section a, supply and return lines from the surface. It is expected that these lines will require 12.0" dia space for the pipe, insulation and support brackets.
2) Section b, external distribution system to manifold the LCW to the barrel toroid, the north end toroid caps and the south end toroid caps. These lines consists of 6.0" dia pipes for the barrel supply and return, and 4.0" dia pipes for the end caps. additional 4.0" diametrical space will be needed around the pipes for insulation and support brackets.
3) Section c, internal distribution system to manifold LCW to the individual coils on the barrel toroid, the north end toroid caps and the south end toroid caps. This system consists of 4.0" dia supply and return manifolds on the face of the barrel at each end and 2.0" dia manifolds for the toroid end caps. The individual coils are supplied from these manifolds via 3/4" flexible hoses. Figure 3 shows a schematic of the LCW internal distribution and manifolding system.

The performance specification of the LCW system at the point of supply and return in the experimental hall is the following:

cooling capacity	=	2,536 kw + 15% spare
LCW flow rate	=	843 gpm + 25% spare
minimum supply temperature	=	60 °F
ΔT in coils	=	20 °F
maximum supply pressure	=	225 psi
Δp max in the hall	=	100 psi @ 57 meters below grade
internal piping pressure rating	=	250 psi

B. LCW System Interface, WBS, Cost and Schedule

The LCW basically provides cooling to the muon toroid system. Therefor, it is not a common utility shared by other subsystems. However, because general utility specialists are familiar with LCW systems, sections of the LCW system will be the responsibility of the ME Integration Group and the SSC Lab Physics Div.

The following are the interface points for the purpose of design, WBS, cost and schedule:

SSC Lab Physics Division

The SSC Lab is in charge of preparing the design, WBS, cost and schedule documents for the LCW system on the surface and down to the main distribution manifold in the hall, Section a above. That includes all surface facilities associated with the production, circulation and distribution of the LCW system (heat exchangers, pumps, de-ionization system, piping in and out of the hall and instrumentation).

This system will be scheduled for completion prior to the installation of the muon toroid system.

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SDC Mechanical Integration Group

The SDC ME Integration Group will be responsible for the design, WBS, cost and schedule of Section b above, i.e., the distribution system from the main supply and return lines in the hall to the internal distribution manifolds on the detector. This part of the effort will appear in WBS Section 7.1.2.

This system will be scheduled for completion prior to the installation of the muon toroid system.

Muon Toroid Group

The muon toroid group will be responsible for the design, WBS, cost and schedule of the LCW system, Sect. c above. That system consists of the internal distribution manifolds for the barrel and end toroids, supply and return lines to the coils, instrumenting and flow control devices. The MIG will provide support service regarding the design and pipe routing of this system. This part of the effort will appear in WBS Section 3.1.

The time required to install Section c distribution system will be included in the muon toroid installation schedule.

III. Gases for Muon Chambers and Tracking Systems

Gas mixtures for the muon chambers are not yet defined. However, it is expected that the forward muon chambers will have a different gas mixture from the barrel chambers. Gases for the tracking system are also not defined at this time.

As the specific engineering requirements for the gas system are developed, detailed piping and the utility support system on the surface and in the hall will be generated. What is clear at this point is that we need the following gas subsystems:

a) Surface facilities for gas mixing and transfer lines to the hall and
b) Hall main distribution and manifolding system
c) Main Distribution manifolds located on the barrel and forward muon chambers.
d) Distribution system to the individual muon chambers including flow control valves and instrumentation.
e) Any other flow control equipment that need to be located in the hall.

Figure 4 shows a cartoon of the gas flow distribution system to the muon chambers. The barrel muon chambers are connected to main supply and return manifolds located at each face of the barrel muon steel. Each octante has its own distribution manifold which run axially along the octante and connects to the barrel main manifolds. The north and south forward chambers are connected to their separate distribution manifold system.

A. Gas System Interface, WBS, Cost and Schedule:

Design specifications, WBS, cost and schedule is the responsibility of the muon chamber group. The SSC Lab Physics Div. will provide the support work for the design, construction and installation of subsystem (a) above, and the Mechanical Integration Group will provide support work for subsystem (b, c, d and e). This part of the effort will appear in WBS Sect. 3.2.

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IV. HVAC System

For a more detailed description of the HVAC system, see Appendix B. For the purpose of system interface and WBS the following description will suffice.

A. Normal hall air conditioning system

This subsystem controls the temperature and humidity level in the hall and provides air changes capability during normal operating conditions. The heat load in the hall is mainly due to lights, pumps and motors in the hall in addition to 5% of the heat dissipated from electronic equipment in the gallery and racks around the outer muon chambers.

The hall subsystem specification are:

Heat Load	=	TBD kw
Minimum supply temperature	=	55°F
Average hall relative humidity level	=	55% ?
Return air temperature	=	75°F
Minimum air changes	=	2 per hour
Outside air recirculation	=	1/2 changes per hour

The air coils for this system are located on the surface and conditioned air is delivered to the hall from both utility shafts. A schematic layout of the distribution system in the hall is shown in Fig. ??.

B. "Emergency" hall ventilation

The emergency hall ventilation system uses the same normal supply system duct work with the following additions:

1) Standby air circulation units are activated to double the air flow to four air changes per hour.
2) 100% of air supply to the hall is outside air.
3) Suction vents are located at ceiling level for smoke evacuation and at the lowest floor level for evacuating heavy gases.

C. Detector ventilation system

Air flow is required inside the muon steel for the removal of any trapped dangerous gases and about 5 to 10% of the electronic heat load. The location of supply and return ducts to the detector are not specified yet. However, the system is expected to be negative in pressure relative to the hall so leaked gases will not defuse into the hall. The down side of this scheme is that the hall air, along with any impurities, can leak into the detector space. This can cause serious problems to the electronic crates if there is a small fire in the hall near the detector.

As shown in Fig. ??, the detector ventilation system will have an independent a/c and fan units on the surface and separate supply and return ducts from the hall normal ventilation system. The performance specifications of the detector ventilation system are:

Heat Load	=	TBD
Supply Temperature	=	75°F
Max return air temperature	=	80°F
Relative humidity level	=	50%

Maximum allowable air speed inside the detector	=	TBD
Minimum air changes	=	8 per hour

D. HVAC System Interface, WBS, Cost and Schedule

The HVAC system is broken down as follows:

The SSC Lab Physics division is responsible for the design and construction of all the ventilation systems. That includes all surface facilities (chillers, pumps, fans, air/water coils and control system), shaft duct work and distribution in the hall. The distribution inside the detector is the responsibility of the SDC MIME Integration Group. This part of the effort will appear in WBS Sect. 7.1.3.

Normal hall and safety ventilation systems are expected to be completed by the hall occupancy date. Duct work for distribution inside the detector will be completed two weeks after the insertion of the tracking system is completed.

V. Cryogenic System

The super conducting solenoidal magnet is the major user of cryogenic fluids where both liquid helium and liquid nitrogen are required. In addition to that, some minor cryogenic requirements are needed by other subsystems. Mainly, the VLPC's require about 100 W of helium refrigeration at about 10°K and nitrogen gas at room temperature will flow in the annular space between the silicon and straw tracking system at a rate of 35 air changes per hour.

The design specification for the solenoid cryogenic system requires helium and nitrogen control dewars to be located in the hall. The supply lines to the dewars will also be used to provide the He and N2 flow for the VLPC's and the silicon tracking system.

The major components of the cryogenic system are:

Surface facilities
- LP He gas storage
- HP He gas storage
- LN2 storage
- He Compressors and oil removal facilities
- He cold box, purification, regeneration and expansion devices
- LHe storage dewar and subcooler
- LHe and LN2 circulation system
- Cryogenic control panel

Shaft equipment
- 12.0 inches transfer line, see Fig. ?? for the details of the transfer line
- 3.0 inches He warm gas return
- 6.0 inches relief
- 4.0 inches nitrogen gas vent (could also use the 6.0" dia relief line as the N2 vent)

Hall equipment
- He control dewar
- LN2 control dewar
- Turbo and roughing pumps
- Transfer lines
- GHe and N2 gas boilers

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Equipment in the detector

- Transfer line between control dewar and the magnet 12.0" dia, see Fig. ?? for the details of the transfer line
- 3.0 in. dia helium supply from He control dewar to VLPC's
- 3.0 in did warm helium return from VLPC's to the control dewar
- 2.0 in. dia room temperature GN2 to silicon tracking
- 2.0 in. dia GN2 vent line from silicon tracking

The cryogenic system design specification was completed by the solenoid magnet group at Fermilab. Figures ?? and ?? show a simplified schematic of the cryogenic system. The cryogenic chimney inside the detector is routed straight up through the muon system at the twelve o'clock position. On top of the detector, the helium and nitrogen control dewars and the vacuum pump will be located.

Figure ??? shows the transfer lines routing in the hall and into the shafts. As shown in the figure, the line will cross the hall space to the same wall where the electronic racks are located, western wall. This layout would leave free the space nearest to the eastern wall for crane access.

A. Cryogenic System Interface, WBS, Cost and Schedule

Design specification and cost estimate of the cryogenic system are the responsibility of the solenoidal magnet group. All the cryogenic equipment will be included in WBS Sect. 4.2, including any equipment required for connecting transfer lines to the VLPC's and the tracking system. The magnet group is also responsible for installing all the cryogenic equipment on the surface, in the shafts and in the hall.

The SSC Lab Physics Div will lay out the surface cryogenic equipment and the buildings required to use it.

The SDC ME Integration Group is responsible for routing the transfer line inside the detector and within the hall (i.e. which wall or shaft to use) in addition to allocating the location in the hall for the cryogenic dewars and pumps in the hall.

The schedule for completing the installation of the cryogenic equipment is the responsibility of the magnet group.

VI. Butane and Chilled Nitrogen Gas for the silicon Tracking System

The silicon tracking system requires butane for cooling and chilled (5-10 °C) of GN2 for precooling and cooling the joint of the electric vaporizer. In addition to that, room temperature nitrogen gas is needed to inert the annular space between the silicon and fiber tracking systems. This room temperature GN2 system is already considered in the cryogenic section discussed above.

The performance specification of the butane and chilled nitrogen system has been completed by the silicon group. Figure ??? shows a schematic layout of the required equipment. Briefly, the system consists of:

Surface Facilities

- Butane supply and circulating compressor
- 50 KW chiller operating at zero °C
- Ethylene Glycol circulation system
- Supply of warm GN2 (available from main N2 supply dewars)
- Nitrogen gas refrigerator and heat exchanger
- Nitrogen gas circulating compressor

- Butane vapor vent/combustor
- Control Panel

In The Shafts

- Butane supply and return lines
- Butane vent line
- Ethylene Glycol supply and return lines
- Chilled Nitrogen supply and return lines
- GN2 vent line (This is common with the cryogenic vent line mentioned in the cryogenic section above.)

In the hall

- 40 KW Butane condenser
- Local Glycol storage tank (to eliminate the head pressure)
- Ethylene Glycol circulation pumps
- Safety and monitoring equipment

Inside the detector

The following transfer line penetrate the muon system:

- 4.0 in dia butane supply line
- 6.0 in dia butane gas return line
- 2.0 in dia chilled GN2 line for cool down
- 2.0 in dia chilled GN2 line to cool the flange joint
- 4.0 in dia line for GN2 relief
- 3.0 in dia line for room temperature N2 supply
- 3.0 in dia line for room temperature N2 return
- Safety and monitoring equipment

A. Butane and Chilled GN2 System Interface, WBS, Cost and Schedule

The butane and chilled GN2 system are the responsibility of the silicon tracking group. That includes surface facilities, piping in the shafts, hall equipment and piping and manifolds inside the detector. The effort will be part of WBS Sect. 1.1. The SDC ME Integration Group will work with the silicon tracking group to determine the location and the routing of the piping system in the hall and inside the detector.

The completion schedule of this system will be completed by the silicon group.