

Calibration of Fuji Prescale Pressure Sensitive Film

TS-SSC 91-134
S. Delchamps
July 8, 1991

Abstract: Calibration data for Fuji Prescale MS and HS films are presented, which should make possible the conversion of measured pressure to actual pressure. It is found that there is a region of relative uncertainty between 6 and 8 kpsi actual pressure, in which both HS and MS films will return ambiguous results.

Introduction: Calibration measurements have been made with Fuji Prescale pressure sensitive film [1], a ~5 mil thick film sheet with polyester backing containing colorant capsules which burst on exposure to pressure, releasing a chemical which turns red when it mixes with a developer also contained in the sheet.

Test strips of Fuji Prescale HS (high pressure, single sheet) and MS (medium pressure, single sheet) were clamped between two flat blocks of tooling steel of different areas. (See Figure 1.) The smaller area block had area 1" x 1", so that the exposed (reddened) regions on the test strips are 1"x1" squares as shown in Figure 2¹.

Clamping pressure was supplied by one of the IB3 Enerpac hydraulic presses². Hydraulic pressure was controlled manually and read out with the IB3 high pressure control unit³. The pump pressure could be controlled to better than ± 10 psi [2]. On each test pressing, the pressure was brought up slowly, and was allowed to remain at the maximum pressure for at least one minute [2]. This insures that the "long duration" settings of the FPD303 are appropriate for reading out the test strips [1].

Hydraulic pressures of 500, 1000, 1500, 2000, 2500, ... , 7000 psi were used. To convert from pump pressure to the pressure on the test strip block, it is necessary to multiply the hydraulic pressures by a factor of 2 [3]. Therefore, the range of pressures to which the test strips were exposed was 1000 - 14,000 psi. The 500 pump psi (1000 psi actual pressure) square showed quite irregular coloration, and so is not included in the results below.

A test strip of Fuji MS Prescale film was exposed to pressures between 1000 and 8000 psi. A test strip of Fuji HS Prescale film was exposed to hydraulic pressures between 8000 and 14000 psi.

¹The actual Fuji Prescale test strips and raw data may be obtained from S. Delchamps. Imre Gonzy has the flat tooling steel pressing blocks.

²Enerpac C-1010 jack. (10,000 psi max with 1 1/2 " diameter cylinder.)

³Power Team Model PQ20 Series High Pressure Power Unit, read out with Sensotec A-10/6079-05 pressure sensor w/ Simpson LED read-out.

Analysis: To measure the pressures recorded by the Fuji Prescale film test strips, the FPD301 densitometer and FPD303 printer were used [1]. The densitometer is sensitive to a circular area with 2 mm diameter. When the exposure button is depressed, four readings are made during a time interval of 0.6 seconds.⁴ The FPD303 can average over as many as five such readings.

Three pairs of measurements were done on each square, as shown in Figure 3. Each measurement consisted of a set of five "slides" over a square. The FPD303 reported the minimum, maximum, and mean value of the slides contained in each measurement. Table 1 shows the results of these measurements. The values in the second and third column of Table 1 are the mean and R.M.S. of the set of six mean values reported by the FPD303 for each square⁵. The units employed by the FPD303 are kg-f / cm**2. In Table 1, the values are given in kpsi⁶.

Calibrated Pressure (kpsi)	Measured Pressure (kpsi)	R.M.S. (kpsi)
MS type film		
2	2.03	0.41
3	3.61	0.36
4	4.39	0.97
5	5.02	0.67
6	5.65	0.51
7	5.94	0.57
8	6.14	0.11
HS type film		
8	10.27	2.13
9	10.81	2.32
10	11.63	2.20
11	13.35	2.46
12	14.63	1.75
13	14.46	1.64
14	16.25	1.14

Table 1. Calibrated and Measured Pressure for Fuji Prescale HS (high pressure) and MS (medium pressure) Type Films

⁴This time interval is long enough for the device to be slid along a surface of varying color density, a procedure used in these measurements and in measurements of film strips taken from the midplane and pole surfaces of a set of test coils.

⁵More complete raw data is available on request from S. Delchamps.

⁶ kpsi = .01422 x kg-f/cm**2

Figure 4 shows a plot of the Table 1 data, with the mean and R.M.S. pressure as measured by Fuji Prescale film versus the calibrated pressure known from the Enerpac press.

It is seen that for pressures between 2 and 6 kpsi, the MS Prescale film works quite well. For pressures higher than 6 kpsi, this film begins to show some saturation effect. For pressures above 8 kpsi, the HS Prescale film appears to behave fairly linearly, but appears to read systematically higher than the calibrated pressure.

Figure 5 shows the points from Figure 4 "inverted." This graph may be used to read off, for a given measured Fuji film pressure, what the "actual" pressure present is. There is a gap between about 6 and 10 kpsi in which no accurate knowledge of the pressure may be obtained with either the HS or MS film. This problem needs careful study, since this pressure range is relevant to the study of end clamp and collared coil loading.

Further Work Needed: Further measurements should be made to obtain more accurate knowledge of the response of the High pressure film in the region between 6 and 8 kpsi. Better values for readout uncertainty should be obtained over the entire pressure range of interest. Perhaps most important, the effect of time lag between exposure and reading should be examined. A set of test squares could be exposed and read several times at set time intervals following exposure.

References

- [1] TS-SSC 91-133, "Instruction Manual for Fuji Film Densitometer FPD301 and Printer FPD303."
- [2] Imre Gonzy, private communication.
- [3] Eric Haggard, private communication.

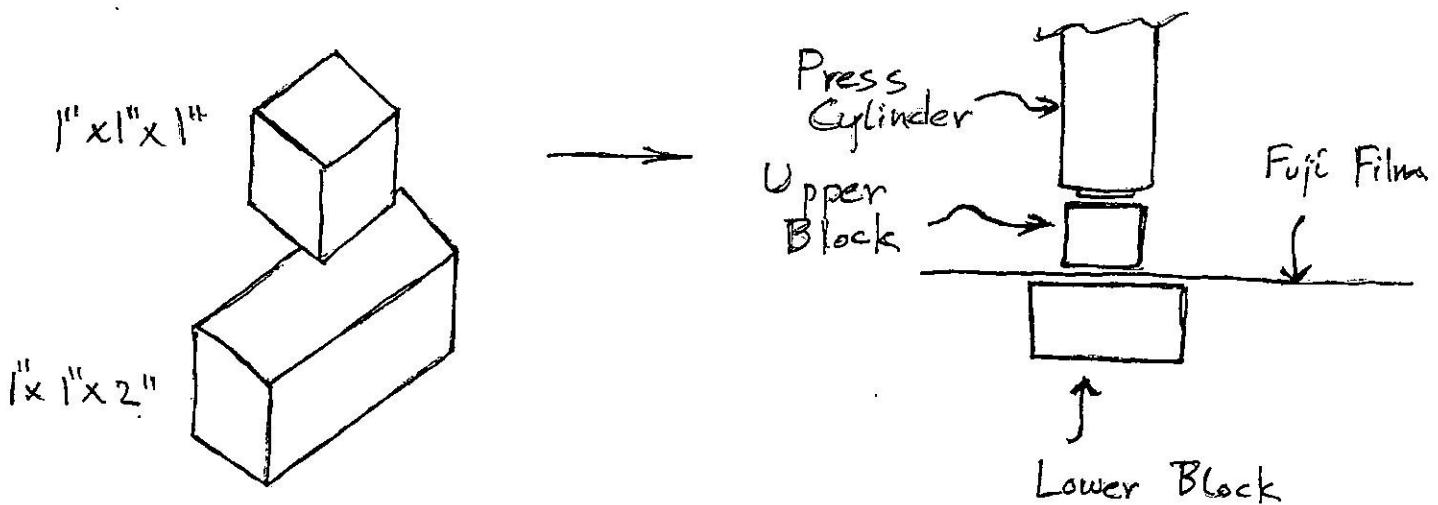


Figure 1. Tooling Steel Blocks

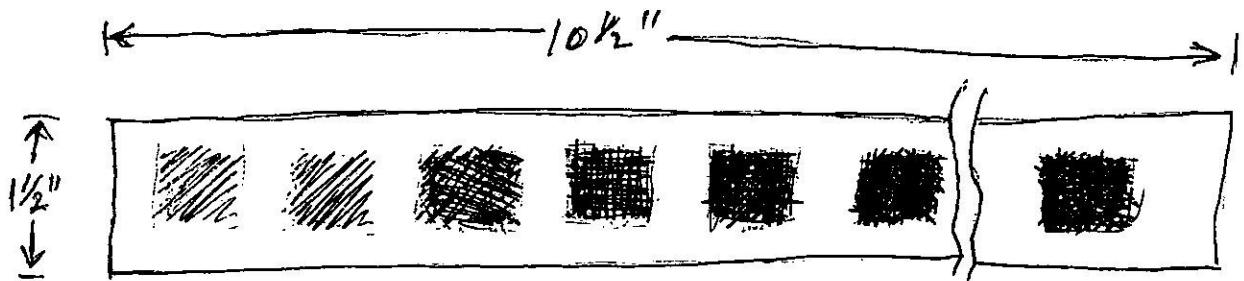
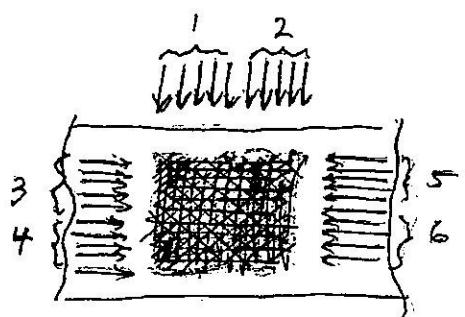


Figure 2. Fuji Prescale Film Test Strip
After Exposure



Arrows indicate direction of FPD301 slide across square. Each reading printed by the FPD303 averages 5 slides.

Figure 3. Measurements Made on a Test Square

Test Strips 2 and 3

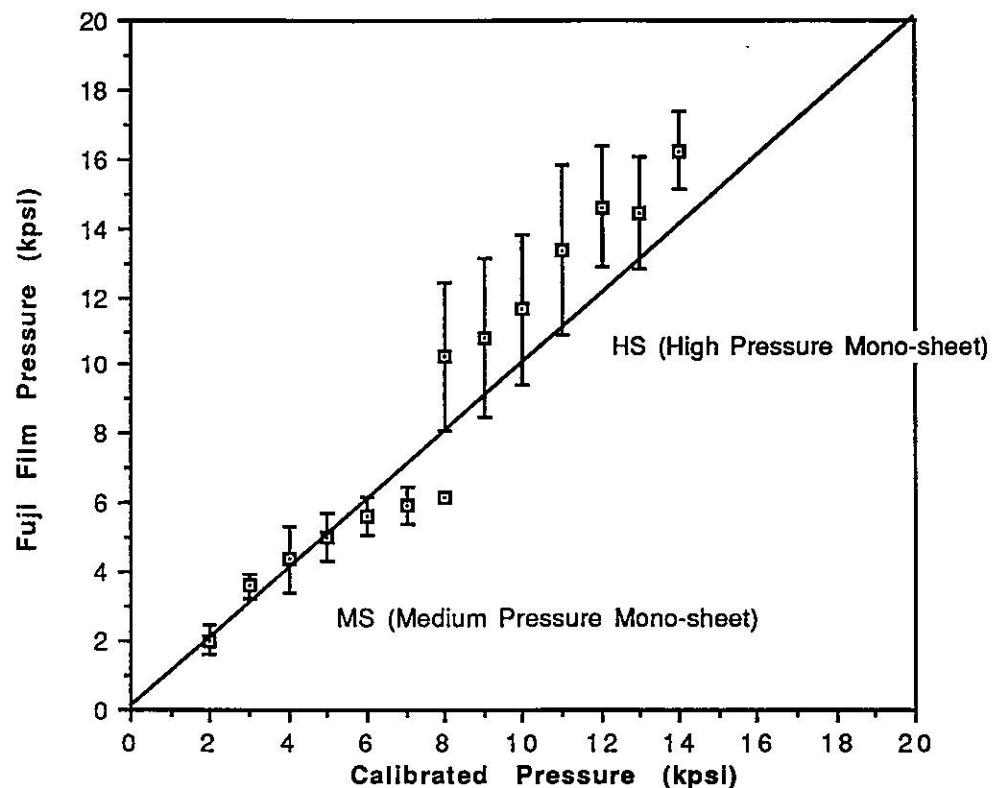


Figure 4. Measured Pressure vs. Calibrated Pressure for MS and HS Films

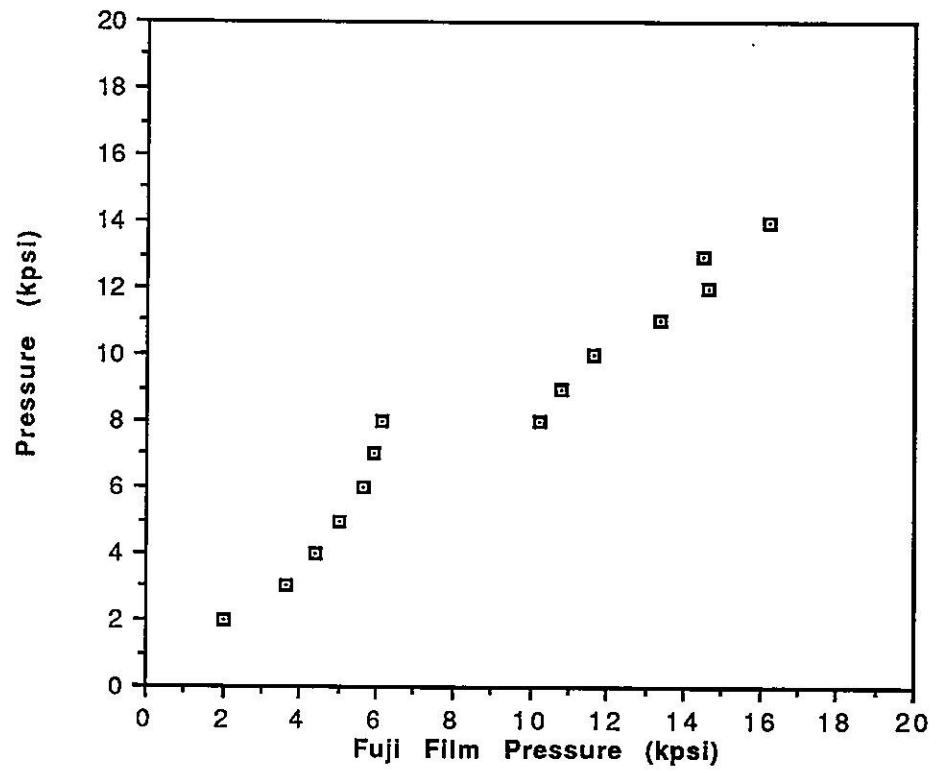


Figure 5. Conversion from Measured to Actual Pressure