CALIBRATION OF STRING 9/12/94.

Set up Wild Catheter... focussed on both ends of string.

<table>
<thead>
<tr>
<th>LOAD (lbs)</th>
<th>BOTTOM</th>
<th>TOP</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>583.97</td>
<td>779.88</td>
<td>195.91</td>
</tr>
<tr>
<td>1000</td>
<td>584.69</td>
<td>780.20</td>
<td>195.51</td>
</tr>
<tr>
<td>2000</td>
<td>585.30</td>
<td>780.44</td>
<td>195.14</td>
</tr>
<tr>
<td>3000</td>
<td>585.93</td>
<td>780.69</td>
<td>194.76</td>
</tr>
<tr>
<td>4000</td>
<td>586.57</td>
<td>780.90</td>
<td>194.33</td>
</tr>
<tr>
<td>5000</td>
<td>587.18</td>
<td>781.13</td>
<td>193.95</td>
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<tr>
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<td>587.73</td>
<td>781.31</td>
<td>193.58</td>
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<tr>
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<td>588.29</td>
<td>781.50</td>
<td>193.21</td>
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<tr>
<td>8000</td>
<td>588.92</td>
<td>781.69</td>
<td>192.77</td>
</tr>
<tr>
<td>9000</td>
<td>589.49</td>
<td>781.88</td>
<td>192.39</td>
</tr>
<tr>
<td>10000</td>
<td>590.07</td>
<td>782.04</td>
<td>191.97</td>
</tr>
</tbody>
</table>

Linear regression (Potdam logbook 6/21/94) gives 11.33 kN/mm.

One way down, approached from below at each pt.

<table>
<thead>
<tr>
<th>LOAD (lbs)</th>
<th>BOTTOM</th>
<th>TOP</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000</td>
<td>590.07</td>
<td>782.06</td>
<td>191.99</td>
</tr>
<tr>
<td>9000</td>
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<td>781.88</td>
<td>192.34</td>
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<td>192.79</td>
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<td>588.34</td>
<td>781.50</td>
<td>193.16</td>
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<td>781.30</td>
<td>193.51</td>
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<tr>
<td>2000</td>
<td>585.39</td>
<td>780.49</td>
<td>195.10</td>
</tr>
<tr>
<td>1000</td>
<td>584.77</td>
<td>780.28</td>
<td>195.48</td>
</tr>
<tr>
<td>100</td>
<td>584.06</td>
<td>779.96</td>
<td>195.84</td>
</tr>
<tr>
<td>(50)</td>
<td>584.00</td>
<td>779.88</td>
<td>195.88</td>
</tr>
</tbody>
</table>

Linear regression: 11.475 kN/mm

Mean = 11.40 kN/mm
\begin{align*}
1 \text{ psi} &= \frac{6.8948 \times 10^3}{\text{Pa}} = 0.0068948 \text{ MPa} \\
1 \text{ lb} = 4.4482 \text{ N} \\
\end{align*}
Config of Analog Devices 3B-18 units:

Gain: TR34

Converting pressure (ConInd): Cell V for 10V excitation is 10.941 mV for 700 MPa.

We want 0-10V to correspond to 0-700 MPa.

Gain in 3B-18 = \( \frac{10,000 \text{ mV}}{10.941 \text{ mV}} = 914.0 \)

Gain-setting resistor:

\( R_3A = \frac{200,000 \Omega}{914} = 218.8 \Omega \)

We need a 219.2 resistor ±5% (229 > R > 208)

Actually fitted

External load cell

Transducer tech: (No 70744) re-calib 20,000 lb = 25.989 mV/10V

We want 0-10V to correspond to 0-180 KN.

Gain in 3B-18 required = \( \frac{10,000}{29.214} = 342.3 \)

Gain-setting resistor:

\( R_3A = \frac{200,000 \Omega}{342.3} = 584.5 \Omega \)

As we need a resistor 613 > R > 555

Volume meter, Port Pressure Transducer (Precision sensors no 42095)

Cell V for 10V excitation is 28.38 mV for 60,000 PSI = 413.69 MPa or 34.30 mV for 500 MPa.

Gain in 3B-18 required = \( \frac{10,000 \text{ mV}}{34.30 \text{ mV}} = 291.5 \)

Gain-setting resistor:

\( R_3A = \frac{200,000 \Omega}{291.5} = 686 \Omega \)

As we need a resistor 720 > R > 652

Actually 680
Downstream port pressure (Pressure sensor no. 42094)
Call for 10V excitation, is 29.84 mV 

\[ \frac{29.84 \text{ mV}}{10 \text{ V}} = 298.4 \text{ psi} \]

Gain in 3DB required is 

\[ \frac{10,000 \text{ mV}}{36.066 \text{ mV}} = 277.3 \]

Gain setting resistor

\[ R_A = \frac{200,000 \text{ ohms}}{277.3} = 721.52 \text{ ohms} \]

So we need a resistor

\[ 757 > R > 686 \]
had to meet connorville to return water to get cauld to

L.P. News today 2-8, 13 + 35 closer 0 & 0.

Cloudy wind to 8-14 mph

9 am to 8-14 mph

In terms of air disturbances (wind &c.)

12 -3

331 ft. 18/18

Piccup
date

26/1/65

24
Touchpoint = 33.2

\[ \sqrt{span} \]
Internal load cell circuits

1. Analog devices demod. unit burst out - sent back to A.D. - was being used with Babcock pre-amp.


3. New LVM-110 installed - seems to work

Set-up procedure:

(1) Picked off AC output from TP1 on pre-amp board & measured using Fluke meter (this is still on Rotdam 160)

(2) Pick up DC at TP1 on distribution board & zero output (this gives zero on meter with zero-offset pot at 500)

(3) Set span at LVM110 to give output at load as reg. value (appears same on 6LC)

Raw hysteresis loop to nominal 85 kN on spring of then on block.

Subtracting apparatus def gives 83 - 1 = 73 mm for 80-10 = 70 kN. 7.3 x 11.4 = 83.2 kN instead of 70 kN, ie reading 19% too high.

Max hysteresis is about ± 0.5 kN on 80 kN span without apparatus distortion correction. But with block load is about ± 2 kN hysteresis at give POS.

At given load, the up & down POS readings are closer on the block than on the spring, so the hysteresis in the spring is actually a little worse than ± 0.5 kN, maybe around ± 0.8 kN or so.
High freq. noise on CP

6. AD
5. IF
4. EF
3. CP
2. VPP ??
1. PPD

TP 327

Talk to Alon about "phase shift" in Potsdam & how to cure.
Write out for George how to set up LLC in Potsdam.
General Testing
The PICS just back from after much to 10C.
Powerline connected.
MIT ILC installed with spring.

ILC
Tried to zero AC output, could get down to ~70mV
but ran out of pot. ILC reading ~ 11 kN.
Set IZ zero shift on 500.
Used the demod. zero shift to put meter reading
to zero. Had to iterate a bit. Bridge not being
properly zeroed.
 Ran an X-Y plot on spring
  "  " block.

In subtracting, there appears to be an increase in slope at
about 20 kN of 10% at 50. The slope itself is about 52% of
what it should be. The ELC appears to have the
same error in it (as noticed before, based on 11.4 kN
per mm for the spring).
W&W channels:
6 AD 5 IF 4 EF 3 CP 2 T 1 PFD

\[ \begin{align*}
6.5 & \quad 3.8 \\
4.2 & \quad 4.7 \\
3.6 & \quad 3.5 \\
3.6 & \quad 3.5 \\
3.0 & \quad 3.5 \\
\end{align*} \]

PID
A, PsZ

Installed 2-fold pump in W&W.

Volumeterai hunting, even at PID = 0, 0, 0.

Eurotherm config [CONF]

1. 0005 RH
2. 00.10 Channel 18-2 separate normal, PID heat
3. 0000 alarm 18-2 de-energized in alarm
4. 3000 multiprogrammer, running, error drain, implicit
5. 3000 K
6. 1300 returns to default, security open, Prop only, English, T/Co display XXXX
7. 0000 model, no paint, 9000 baud, ASC II BI-SYNCH
8. 0000 no analog, normal, no analog inputs, no analog output, no offset
9. 1111 reset, alarm time, 1 self-time available, front & rear
10. 0101 remote: SPI hold, front & rear, SPI hold in manual, Auto/Off-Paint/Local
11. 0003 D C output

we need 1000 f-14

we need 1000 f-14
7/2/95

Overnight Norm worked on PCS to correct problems of scaling & apparent noise on CP (air gain & g927 problem). No pump control output at present. Plan started installing pump connections.

Pump PID: Temporarily P = 150, I = 100 on AD & previous setting P = 50, I = 30 on IF.

Contact 48.5 pm Temp cal: assembly at room temp & pressure. Old parts then re-dressed several times.
Re: ch: (6) (5) (3) c93

Meters: 48.5 0.2 0.9 -0.5 (also 48 meter)

Set in bottle pressure

44.5 1.6 1.4 11.2

44.5 0.7 1.3 11.9 2% water

Pumping on gas booster to 106

Instrument to ~200

In [UNCONF] pump units = 20, 18 minutes.

Approximately the same setting is in K per min.

Set 20 k/ mm

B winding: 13.8 A 23V R = 1.67Ω

Furnace windings: terminals at wall are in opposite order to usual, ie instead of B, C, T from the door (as the Thermocouples still are). They are T, C, B.
We re-connected the furnace leads this way in order to get bottom power into bottom winding.
When I turned off main power, on again, the TP und WO 65 got lost on channels 405, I went to MAC. They were still configured, I got connected up again as I got the config screen.

On MAC for TP [ADS initial setup screen]
actual IF 2.7kN
Set TP 7.0kN
9 initialized
POS was 45
When actuated at +10μm s⁻¹ actuators ran in opposite direction until stopped at POS 42.7 (Why didn't drop limit come on?) Tried again went to POS 41.3 - still not at limit. Changed actuator speed to −10μm s⁻¹. Still runs in wrong (same/down) direction.

Press 6 to enter OPER mode
1 to hold
6 to scroll for SP
4025 to show SP value
4025 again to change value at what time the pump clamps will show.
2 to hold clamp
2 again to release hold
787 power seems to take B ammeter on to current limit.

1LC at -2.6 when left - just after dropping pressure.
Next morning 1LC 0.0 45.1 0.0 6.9 -12.0.

CP up to 212 mpa.
Heating without contact. zero 1LC. 27. ELC. 5.0.

Initial load of 4.9KN relative to zero of 2.0.
Applied manually.

1st profile central T/C 600 % P. o/p 49%. X (T/C jammed)
T & T dropped in order to investigate.
T/C stuck but not damaged when freed.
Re-pressured system & ramped back to S.P. (600)

Int. force applied manually at 4.05 KN (relative to zero of 2)

1st profile central T/C 600 % S.P. o/p 49%. 
Same setting (750/9/100)

20° " " " 880K " o/p 59% 

30° " " " 858K " o/p 58% 

40° " " " 828K " o/p 53% 

50° " " " 775/350/930

Profile 6. 760% central T/C. TOP

SPEC TEMP 9.62

T A V \n335/700 103 10 103 775 \n648 4.9 13 627 350 \n315 13 17 221 9.50

R.T. 387 0.59 Wk⁻¹

LOST AGAIN
Profile 7, 750K Control S.P.

\[
\begin{array}{|c|c|c|c|c|}
\hline
T & A & V & P & ADJ \\
\hline
751 & 10.6 & 14 & 148.4 & 775 \\
692 & 4.85 & 16.5 & 79.2 & 350 \\
B R & T & 13.3 & 19 & 252.7 & 950 \\
\hline
\end{array}
\]

\[
0.65 \text{ W/K}^2
\]

SPEC TEMP 1045 K

{\text{Fed to B actuator before switching furnace 96.}}
Internal Load Cell Zero

Spent some time with Alan F. on why the bridge including the UC could not be fully zeroed.
We measured the capacitances with the stem attached: 75.5 pF upper 69.1 lower.

and at first thought this should be within the 8002 range of adjustment in the other half bridge of total resistance 1000k (430 + 160 + 430).
However these capacitances include that grey 1M stem leads to earth, probably around 36 pF?
If we take 30, then the plate capacitances are assumed 45.5 39.1 = 1.16
whereas the extreme adjustment range on the other half bridge is 53 1.23
If the leads had 40 pF to earth, the plate capacitances would give 35.5 22.1 = 1.22.
Presumably the ratio is slightly more than this since we could not quite balance the bridge.
So a 500k pot was put in in place of the 100k pot (did not have a 20k one handy).

'New' balanced easily, finishing with less than about 10mV signal as observed on the CH0.
Zero reading on AI meter now -16.3 with goo pot on front panel at 500.
Re-zoned on the unit's board.
1 lb = 4.448 N
1000 lb = 4.448 KN
External Load Cell Calibration

This seems to be off 20% compared to the string. So checked up with Ample, reading on the A/C meter with same settings as before.

<table>
<thead>
<tr>
<th>Load (kN)</th>
<th>A/C Mtr reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.00</td>
<td>10</td>
</tr>
<tr>
<td>2.00</td>
<td>53</td>
</tr>
<tr>
<td>3.00</td>
<td>8.9</td>
</tr>
<tr>
<td>4.00</td>
<td>12.4</td>
</tr>
<tr>
<td>5.00</td>
<td>15.6</td>
</tr>
<tr>
<td>6.00</td>
<td>19.3</td>
</tr>
<tr>
<td>7.00</td>
<td>22.7</td>
</tr>
<tr>
<td>8.00</td>
<td>26.0</td>
</tr>
<tr>
<td>9.00</td>
<td>29.2</td>
</tr>
<tr>
<td>10.00</td>
<td>32.4</td>
</tr>
<tr>
<td>11.59</td>
<td>35.8</td>
</tr>
</tbody>
</table>

Cumming loads:

<table>
<thead>
<tr>
<th>Load (kN)</th>
<th>A/C Mtr reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00</td>
<td>44.5</td>
</tr>
<tr>
<td>9.00</td>
<td>35.7</td>
</tr>
<tr>
<td>8.00</td>
<td>32.4</td>
</tr>
<tr>
<td>7.00</td>
<td>29.2</td>
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<tr>
<td>6.00</td>
<td>26.0</td>
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<td>5.00</td>
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<td>4.000</td>
<td>16.1</td>
</tr>
<tr>
<td>3.000</td>
<td>12.7</td>
</tr>
<tr>
<td>2.000</td>
<td>9.1</td>
</tr>
<tr>
<td>1.000</td>
<td>5.3</td>
</tr>
<tr>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

This gives a non-linear plot: at 20 kN, the indicated load is 0.84 of the actual, and at 40 kN, it is 0.79 of the actual, i.e. the load cell appears to get less sensitive as the load increases (due to internal strain from earlier overload??)
MIT load cell 70744

The present R3 resistor in the AC1310 card in the conditioning unit gives a range from 32.8 to 40.4 when the load force is at 1N. As we need another resistor 1.22 x lower than the one installed, ie. 0.82 x

Changed 560Ω resistor to 470Ω2 in AC1310.

<table>
<thead>
<tr>
<th>Analog load (lbf)</th>
<th>AIC Up</th>
<th>PICS</th>
<th>AIC Down</th>
<th>PICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.04</td>
<td>0.0</td>
<td>0.09</td>
</tr>
<tr>
<td>1000</td>
<td>1.45</td>
<td>5.3</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>2000</td>
<td>8.9</td>
<td>10.0</td>
<td>10.1</td>
<td>10.1</td>
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<tr>
<td>3000</td>
<td>13.3</td>
<td>14.3</td>
<td>14.5</td>
<td>14.4</td>
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<tr>
<td>4000</td>
<td>17.8</td>
<td>18.6</td>
<td>18.7</td>
<td>18.7</td>
</tr>
<tr>
<td>5000</td>
<td>22.2</td>
<td>22.8</td>
<td>22.9</td>
<td>22.9</td>
</tr>
<tr>
<td>6000</td>
<td>26.7</td>
<td>27.0</td>
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<td>9000</td>
<td>40.0</td>
<td>39.1</td>
<td>39.0</td>
<td>38.8</td>
</tr>
<tr>
<td>10000</td>
<td>44.5</td>
<td>43.1</td>
<td>42.0</td>
<td>42.9</td>
</tr>
</tbody>
</table>

So this load cell is non-linear in its output. The effect is present in mV output 9 in the AIC/PICS readings. E14 cell is OK, so the effect must be in the cell itself.
Copy Analog Devices 9 pin or span setting info from manual.
<table>
<thead>
<tr>
<th>Load (KN)</th>
<th>0</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>5000</th>
<th>6000</th>
<th>7000</th>
<th>8000</th>
<th>9000</th>
<th>10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>mV UP</td>
<td>0</td>
<td>0.6</td>
<td>1.3</td>
<td>3.9</td>
<td>5.2</td>
<td>6.5</td>
<td>7.8</td>
<td>9.1</td>
<td>10.4</td>
<td>11.7</td>
<td>13.0</td>
</tr>
<tr>
<td>mV DOWN</td>
<td>0</td>
<td>0.6</td>
<td>1.3</td>
<td>3.9</td>
<td>5.2</td>
<td>6.5</td>
<td>7.8</td>
<td>9.1</td>
<td>10.4</td>
<td>11.7</td>
<td>13.0</td>
</tr>
</tbody>
</table>

So ETH load cell is linear; slight offset voltage on meter but not in mV – must be in the ETH load cell.
The nano has 10 JID resistors.

Set AD PID = 40/0/0 - not enough.

If wheel is activated, 0-0 feedback operate again.

TSK freezes.

tSQA is frozen while a selection is on.
Further checks on Internal lead all 4 SPRING
Touch point is ~ 32.8
LC goes slightly negative before going positive, to about 0.3

Let muter at 32.4 -0.1 -0.2 -0.2
Next morning 32.4 0.0 -0.3 -0.4

Tried running X-Y plotter but Z-fold chart paper does not work in recorder.

Need better PID setting
P = 50, I = 0: ok up to about 30 kN but not enough power higher
Try P = 60, I = 0: getting sluggish around 50 kN

could not get above 70 kN, a very slowly stuck at 73.5. Came back with

Next P = 65, I = 0: up to 70 kN or so, slowing up near 80.
P = 65 I = 20: seems slower getting up to AD = 39
F = 75. Slightly overshooting before going down
P = 60 I = 20. Much the same but takes to get up to AD = 39, F = 72. Still hunts twice on

dropping back to AD = 33 rapidly.
P = 50, I = 0 again: only one hunt now.
P = 45, I = 0: slow to get up to AD = 36, F = 36. On

overshoot on descent.
P = 45 I = 40: Slow above ~ 30 kN. Bit of overshoot

on way down, not much.
P = 45 I = 60: slow below V 20 kN then slow again,


better than I = 40: limits at AD = 36.6 F = 42
P = 45 I = 100: Slow steady up? flattens out

again at AD 36.9 F = 45. So not much gain

from I = 40 to I = 100. Something else at end of return.

Try I = 60
$P = 60 \quad I = 60$ Stay up to POS 37, slow to go up to
POS 39, but it did get there (F = 75). Three hours
when it came back.

It turns out I & D were not enabled.

P F & D now enabled on both actuators by Noten.

$p = 40, \quad I = 0$ Goes up & down rather slowly. Slight
over shoot down.

$p = 40 \quad I = 20$ Up faster, sl d'shoot on up.
Down slowly. some d'shoot on down

$p = 40 \quad I = 10$ Similar up & down

Run on MAC, 2 min cycle 40 POS 39 & back. Legged on
way up, sl oscillation on way down.

$p = 40 \quad I = 10$ Leg above ~ F = 20.
nsl oscillation down

$p = 40 \quad I = 20$ Saggish at beginning changes ~ POS 37

$p = 40 \quad I = 30$

$p = 40 \quad I = 40$ Sl lag near POS 39 on way up, lags a
bit on way back.

$p = 50 \quad I = 50$ Sl oscillation on way up, following fairly
well; lag on way down of some sort.

$p = 50 \quad I = 20$ Built up on down

$p = 50 \quad I = 40$ Slight worse, follows well
Some sl d'own, not too bad.

$p = 50 \quad I = 40 \quad D = 409/100.$ Maybe 15 up or 2, a bit

$p = 40 \quad I = 100$ Still some d'own up. Sl lag at top, &
lags on way down.
Running in AD mode on spring

- 0
- 15, 60, 60s
P45  I 30  DO  Move once on way up, stall at top
   but not yet.
P50  I 30  DO  - worse once at beginning
P40  I 30  - quite good at first but lags later
   - etc. on repeat
P35  I 30  - sl double warp up & lag down
   - same on two repeats but evolves a bit
P35  I 40  - better up but bad lag down at first,
   the same once.
Seem to need P > I or need to run several cycles.
P45  I 35  - Still some oscillations hold up &
down after several cycles
P40  I 30  Seems to be best compromise -
doesn't quite get to peak (actuator lags behind the
program a little bit) - the rate is 7 mm in 1 minute
117.5 µm s⁻¹ - on way up, some slight oscillation
and some overshoot on coming back to origin

Run X-Y plot on spring - actuate advanced a
bit further. Repeated.

Then two X-Y cycles on block.
In switching PICS on, channel 5 comes up with 2.39 V and 4 with 2.51 V. Should be close to 5.0 V each. TSCR & MAC both read OK.

On coming out of chest record is screen reading 9.5 V. (Need to set up calib on CP & metr.)

CP solenoid on - not pumping.

Later PM.
Checking pressure effects on UC zero
Block is in pressure vessel, TP @ 32.0, STAD @ 31.0

Let in gas from intensifier @ 5.1 MPa — a kick on UC then quiet. Gas from bottle @ 9.2 — no kick
Pumping up, raised 100 MPa.
Blew 200 MPa rupture disk.
Zero seems to have moved down to below 1.5 MPa.
On letting in gas pressure, big kick on UC.

Pumped to 100, 200 & 300. Now a tendency for zero to go one way & then reverse at each stage (since no pressure decrease).
One pump cut in induced at 3000 — no effect.
Dropped to 200 & 100.
Back to 310.
TP on block is at 32.7 APS; back to 32.2.
Same program as yesterday — hit limit.
Reset to 31.8; repeat.
Dropped P to zero — no jitters at near zero pressure.

Put in spring.
Could not start intensifier pump — turned out to be fault in solenoid valve.
Axial PIP: \( P = 40 \)
\( I = 30 \)

\[ TP \approx 33 \text{ at } 0 \text{ MPa} \]

On hook, \( TP \approx 0 \text{ MPa} \) \( \sim 3 \)
Calib of ILG at 300 MPa

Ran an X-Y plot yesterday on block.

Now put in spring.

Pumped to ~318 MPa, ILG fugue went up to 0.94N.

Ran X-Y plot.

Moved IF zero down to -10 kN and re-zeroed on front pot.

Then +10 kN

Finally back to original zero

Repeated X-Y cycle with an expanded scale.

No hicks at all on dropping pressure.

Repeated X-Y at room pressure on expanded scale.

1) The spikes on the IF bars may have increased with EDM running. They disappeared during the night, so are probably due to artifact interference.

2) The hydraulic pressure was at 200 MPa (known variable)

3) The barbell characteristic shifting up at higher loads, if no

new bars.

4) The barbell is more sensitive at high pressure than at room pressure by ~1.5-20.7
16.2.95

Review of recent observations:

On 13/2/95, the zero shift effect had the same shape with time as observed previously, viz.

\[ \text{inc press. - const press.} \]

After blowing a rupture disk at 174 kPa, the effect became

\[ \text{inc pressure - const pressure} \]

which was reversed on dropping pressure. At atmospheric pressure, the time effect became monotonic.

2) The spikes on the IF trace may have increased with EDM running. They disappeared during the night, so are probably due to external interference.

3) The hysteresis reverses sign at 300 kPa (becomes negative!)

4) The load cell characteristic stiffens up at higher loads, i.e., non-linear.

5) The load cell is more sensitive at high pressure than at room pressure by \( \sim 15\% - 20\% \).
TP in spring 330 at 0.1/1/12

Note: limits on MAC are relative

So if EF is at +15kN on friction when MAC is started, then going to lower friction level of -15kN is 30kN below reference level - i.e. have to set EF limit below -30kN

Increased PID for AD -> 42/30/0
Testing 16C

Begin experiment with AD control, first to test AD by then to run up in stages to two load levels, repeated three times at 0.5kN.

Maxed AD up 0.8mm & repeated at 380 MPa. Hit EF limit after 2 cycles - see lift.
Repeated several times, getting hung up on EF limits mostly.
Just repeat, took actuator down to ~3100s & then up to 32.8 so that the reference EF reading is positive.

Hit 1C limit. The program seems to overshoot a couple times - check.
AD jumps down ~0.05 mm on switching actuator on

10 = ΔP of 7140a
10 ± 3.5/100

179.5

On MAC program, hysteresis = 0.5%. This now shows on TSCR; but pump kicks in & out continuously, giving pressure band of only 1 to 2/100.

I set hysteresis on CP screen at 1%; it was back to 0.5% when I came to next run — OK next run.

If I put actuator on & immediately the TSCR shows AD mode, it seems to trip back to 0.7 SP & runs backwards. When switch on after initializing is finished, it is OK.
Confining pressure control

Yesterday when I tried to use the CP control from PCS, there was some chattering of the solenoid valve at the setpoint so I gave up. Dropped pressure to 100 ± 10% overnight. Checked pump up at 150, setting hydrometer 0.5% same problem.

Found that 35 PCS will only accept 1 or 2% hydrometer if set 0.5% insert 0.9, it sets 0.0
" 1.1 1.0
" 1.5 1.0
" 2 2

Set at 175 with 1% hydrometer, it goes up to 179.5 (ie went up 4.5) and back to 175.8
Trips in at 173.1, out at 179.1, drops to 176.9
for set point of 175.

ie it tracks SP = 175 to 176 gives ~ ± 3 MPa band, this
With SP 300, it settled at 302.9 307.8
302.9 -Δ = 5!

Further LCC tests, same program but starting from
AD = 32.0, IF = 0 EF = -2.8

On first cycle max, it moved up 8 mm -- I thought
I had given 7 mm on program. On checking, it
says 8 mm in program on running screen.
Tripped up on limits. Finally got full program to run.

Then another run (no program) at slow rate up to high load to check smoothness of drive.

Next IF control run with P = 40, I = 30

When running down by manually, EC limit hit at
-13.6 kN when set at ~ -24. Why?
Shifting still at 40.
zero on oil gauge?

Check TP processor diff rates

Not real, PID on TG from max to $P=30\ I=30$

TP procedure does not seem to set speed properly

After a new run on block which finished OK, went back to repeat & found previous program in menu - do we have to put it in at end of set up?

Putting in Test Menu did not work

Still not embedded after next run

See manual
Took CP down to 40/00/41a.
Left running on cycles of IF control.
When using TP, creep, actuator seemed to go very fast & overshoot.
- Check TP behaviour.

Run OK overnight.

23/2/95

Started run on block in IF control, 50 kN amplitude.
Actuator started oscillating at about 45 kN & continued on downward leg. $P = 40, I = 30$.
Still oscillating at $P = 35, I = 25$.
Changed to $P = 20, I = 10$, then $P = 20, I = 15$ stuck at 45 kN.
Next to $P = 30, I = 10$, still stuck at 45 kN.

On next cycle, when pressed TP, IF shot up to ~36 & then back - rate only on Juns'.

Increased $P$ & $I$ to $P = 30, I = 22$.
On one cycle at 0 MPa went into oscillation near end of cycle - stopped by holding motive.

Run similar at 700 MPa.
After one cycle, stopped on EC limit (it was -17, I thought I set it at -40, so must have had 23 kN friction, at start, or -40 was not embedded properly).

Started again.
Left overnight at pressure, only dropped 12 MPa overnight (397.4 in morning).
200
180
30

Zebra

11 = I, 05 = 7
01 = I, 02 = 9

4770 to 9.07.67

z = 1, dz = 3

I P 0200 1 07 088

After a long run on this...
On run B, put in CP ramp down for 30 mins. On
ADS remaining screen, it did not show the CP time;
after 1 minute, it showed FINISH but carried on on
the program.

Ramped pressure down.

Off except for two or three larger steps. Goes down
in hysteresis steps?

24/1/95

Approx. 680/1050. Then went at pumping rate
heads at room + pressure gage. 9. At Man. 7.5 foot
700. 10% on other disk.

A bubble on main at 600/1050.

At 500/1050, had a pumping rate, could hear leak
in top and had water intake valve?

Air trapped at 600. Fanry rapid leak; still leak
from 500 to 700. Restricted all velocities no difference.

Can then go back 700 from leak.

14/1/95

Gusher at 740/1050. No breaking back

Talk to T.Ref 14/11/95. Looking back reminded me 10/95
- 2/11/95
Norm react TG PID from 44000 to P = 30
I = 30
D = 0.

After pressure test, box: 65.084 bottom & centre
65.081 top

Increase in diam. 0.016 to 0.019
0.013 at top
0.022 in centre.
Pressure Test
Previously been to ~500 MPa.
Bore  65.062  centre
      65.068  top

Strengthening well at 500 MPa.
At close to 600 MPa, rupture disk (800 bar) blew.
New one from series 7.92.0705 Pat. 1.4301
(they may have been from series 307.0393  Pat. 1.4401, although we don't have a record)
All 580, leak at pressure transducer & one blank plug.
Pristine pressure transducer seat & put back.
At 620 MPa, leak at connectors from gauge take into 4-way.
Blew 30 MPa rupture disk by stepping.
At 650 MPa, leaks at intensifier valve packing & a couple joints. Tightened

24/12/95

Another try. To ~690 MPa, then leak - pumping rate.
Leaks at entry to pressure gauge & at blank for
700 MPa rupture disk.
Again. A bubble on 4 at 660 MPa.
To 680 MPa, leak - pumping rate; could hear leak.

Can't see any leak; release valve? ?

Again. Stopped at 680, fairly rapid leak, still going.
Down to 500; re-tightened all valve, no difference; no bubbles anywhere.

Again. Same, cannot hold at 600, leaks back to below
500, can hear gas leak; oil not coming back.
Gas blown out of valve into pressure gauge cross,
also out of one valve connection; tightened

Next to 726 MPa; leaking back somewhat; 1 MPa
in 2 sec, 1 MPa in 3 sec at 700.
Dropped back to 600; rebounded to 604.7; now 1.7 MPa/1 min

At 547
- 499: 2.586/1 min
- 495: 0.8 MPa/1 min
- 400: 0.1 MPa/1 min
- 300: 1 MPa/hour.

Finally CP zero = 0.8

Took out load cell.
O-rings rather worn & a lot of RoS on pistons - may be reason for high friction.
Rounded back edge of comp piston head to prevent catching on nitride ring during withdrawal. Assembled again as before.
Still have to go thru chart recorder screen to activate all channels after turning PICS off.

Actuator jumps down 0.08 mm when power put on.

Computer running program but CP program set for hold 10s, with 0.5% hysteresis band. Found that when tried to ramp down on PICS while HAL running that the hysteresis was 0%; reset to 1%, it took it; but would not take SP of 200 MPa—always returned to SP 300 on "return".
Cal again on spring
Program at left
First ran the first cycle at 0 MPa
TP 32.0
Peter fixed a problem on the display screen during running.
Pumped up to 100 MPa
Positioned actuator 1 mm before touch point.
Ran program at left. Start 12:42. 6h 7m to run.
"Finished" program at 500 MPa — why not drop to 380? Screen showed "finished" but it had not
thrown up the "note" screen until 2 pushed stop.
Oil had disappeared from sight but intensity on still
849 apparently not activated from PCS because
it was an hour or so since last actin.
Checked back on program — definitely ramp
down still there. Released pressure
Back to ~ 450 before oil visible
Released to 380
Leak rate at 500 MPa is 1 MPa/hr now
Set new program, ramp up 1 mm in 100 hrs
ie 10 cm/hr
Left at 303.6 MPa (4 MPa in 17 hours, ie 1 MPa/4 hours)
Pumped to 304.6. Need to check out bleed valve setting
304.1
301.2
Stopped run at 35 hours; established 5 mm per hour
Took ~ 1/2 hr to save data, ie ~1 min per hour data.
27/2/95
Out PICS ADS status screen on strain/time
strain span 3, time 7000s
— no trace on screen

Set
27/2/95

Friction on very slow run:

In the 250/4 950 run, the friction was:
100 MPa  4 kN under no load
200    7
300    10-13
500    27-30

In the very slow (10 m/hr) run afterwards at 1300 MPa, 17-18 kN under no load

11C drifted ~ 0.2 MPa during the 35 hr run.

Set up program to ramp pressure down from 300 MPa — does not appear to work, even if bleed valve opened further — on checking found that the program had a 15 min hold in at the beginning.

At this stage, CP status said 1 hr 52 min while ADS status said 1 hr 26 min — have to remember that ADS status may be shorter than some other

Program 4 that “finished” here does not necessarily mean the end of the MAC program

Added D = 10 to AD PID with P = 42, I = 30

20
40
Put block back & set actuator at 31.5 (TP0) = 32.0
(232.2)

For TP screen, set 1 kN; it went to 2 kN & then backed off to 1 with head speed 1/5
Considerable fluctuation on EF while controlling on IF on block. Tried increasing D to 40000, did not help.

Tried chipping I back to 18 - too sluggish.
Back to I = 22; still seems sluggish.

Now P → 35; I = 20

Obviously difficult to control in IF on block - very stiff, machine over-reacts when IF program is overshoot.

Tripped out on FC lower limit (set at -40 kN; there must be a large swing downwards, although ref value could have been up to +20).

12.77 (1 + 0.0086) kN / mm

25.9 kN / mm

1.0% of 100 MP

25.9 kN / mm

1.0% of 100 MP

Reduction in load compared with 0.25% per 100 MP

Reduction in speed compared with 0.25% per 100 MP

Reduction in feed compared with 0.25% per 100 MP

Reduction in depth compared with 0.25% per 100 MP

Reduction in roughness compared with 0.25% per 100 MP

Reduction in surface finish compared with 0.25% per 100 MP

Reduction in accuracy compared with 0.25% per 100 MP

Reduction in band vibration compared with 0.25% per 100 MP

Reduction in chip evacuation compared with 0.25% per 100 MP

Reduction in tool life compared with 0.25% per 100 MP

Reduction in tool wear compared with 0.25% per 100 MP
**Drive Amplitude**

\[ P(sp-FB) + I \int (sp-FB)_{el} = \text{drive to amplifier} \]

Ask Norm about time constant links.

--

Spring constant is 11.40 kN/mm
or 0.0877 mm/kN

When stalled on P1, I adds an equal amount every 10 seconds.

\[ E = E_0 \left(1 + \frac{P \cdot \Delta E}{E_0} \right) \]
<table>
<thead>
<tr>
<th>Pressure (MPa)</th>
<th>Movement (mm)</th>
<th>Calibration (KN/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.0769</td>
</tr>
<tr>
<td>100</td>
<td>0.0077</td>
<td>0.0077</td>
</tr>
<tr>
<td>200</td>
<td>0.0075</td>
<td>0.0075</td>
</tr>
<tr>
<td>300</td>
<td>0.0073</td>
<td>0.0073</td>
</tr>
<tr>
<td>500</td>
<td>0.0072</td>
<td>0.0072</td>
</tr>
</tbody>
</table>

Thus, there is a jump up in stiffness of the load cell from 0 MPa to 100 MPa, but from 100 MPa, calibration gives a linear regression:

\[
(15.97 + 0.00138 \text{ P/MPa}) \text{ KN/mm} = 15.97 (1 + 0.0086) \text{ KN/mm per 100 MPa.}
\]

\[15.97 \times 0.0086 \text{ per 100 MPa increase.}\]

This is 0.9% per 100 MPa increase. This is 0.24% per 100 MPa that the Young's Modulus of iron increases \((dE/dp = 5.1)\).

So there seems to be some additional pressure sensitivity present but it is below the 1% level.

However, there is serious change in calibration, somewhere between 200 pressure & 100 MPa.

Since the spring calibrates 11.40 KN/mm at 100 MPa, it should be 11.5 at 3800 MPa. Thus the forces registered by the ILC are too high by about 43% \((1.426 \times 3800 \text{ MPa})\).
so when 16.5 kN is indicated, actual = 11.40 kN
- have to increase meter readings by 1.45x

They EL must be reading excessively too?
But on 13/12/95, it was set up to read appear correctly.

ie: For 1mm of spring deflection:
    True load = 11.40 kN

Indicated load = 16.50 kN at high loads at 300 MPa

\[ \frac{15.24}{14.45} = \text{low} \]

14.45 kN at high loads at 0 MPa
12.63 " low "

For 1mm of block deflection:
    Indicated load = \( \frac{1}{0.0073} = 137 \text{ kN} \) at 300 MPa
    so true load = 137 + \( \frac{11.40}{16.50} \)
                = 94.65 kN

ie true block apparatus distortion correction = 0.0106 mm/kN

Spring deflection = 11.40 = 0.0877 mm/kN

so total def. with spring = 0.0783 mm/kN

for setting up the meter reading. Eg, 4.91 mm should
give 50 kN/reading
The results on the previous page can be compared with those from earlier calibrations using X-Y recorder (and assuming that the Y scale is the same in actual distance (not in chart divisions) as the X scale:

At 300 MPa:  On 100 kN scale, cal = 16.50 kN/mm  actual 16.49

On 20 kN "  " 15.24 or $rac{3}{4} Y$

So the non-linearity is about 8%.

At 0 MPa,  On 100 kN scale, cal = \( \frac{14.45}{12} \) kN/mm

" 20 " "  " 12.63 "

so non-linearity is now much greater.

The calibrations thus are consistent between earlier & more recent values, and suggest that there is a pressure sensitivity arising from the bedding down of the contact between piston & load cell.

But at my 50kN, we have 3.03 mm displacement at 300 MPa, & 3.46 mm at 0 MPa, it a difference of 0.44 mm.

Similar analysis on the external load cell gave at 300 MPa an 2.5 & 0.5 gives 13.3 kN/mm. If the spring is 14 kN/mm, so there is an extra 1.9 kN/mm in the slope. Could this be friction increasing with load? At 7 kN

= \( \frac{3}{4} \) kN load. The extra "friction" would then be 9.75 kN, ie rising from 10 kN to \( \frac{3}{4} \) kN; but the normal double friction is 28 kN, ie single friction 14 kN, a build-up of 4 kN, not quite enough to correspond—but friction may not be symmetrical there.
The force acting the ILC body on the piston from the containing pressure is 125 kN per 100 MPa of containing pressure. So the extra load should not cause much further change to the seating of the ILC at 100 MPa or above, since the pressure sensitivity of the load zero is very small above 100 MPa, indicating full seating of the ILC.

Thus, it is hard to see that the non-linearity of the ILC response to load is associated with the seating of the load cell. It suggests that it is most associated with the seating of the specimen and support on the top of the ILC, since this is only bearing in the segment.

We cannot see any unevenness in this bearing but there could easily be several microns of difference so that the load could come down on two lugs at first and take up on the other two lugs at higher load. It is not intuitively clear that this would give a non-linearity but it may due to some bending characteristics in the loading distribution of the two lugs, seating fully at around 20 kN.

The bearing area of the lugs is 290 mm², i.e. 145 mm² for two lugs, so 20 kN on two lugs gives a bearing stress of 138 MPa, or a strain of 0.0007. If this is distributed over a depth comparable to the circumferential width of the lug, viz about 18 mm, then the displacement will be 12 mm. Thus a gap of the order of 10 mm would probably delay full loading on four lugs until ~20 kN.
Temp not indicating when NO2 selected on temp.

\[ \text{Temp. Cal was set to } \varnothing 0000, \text{ hence OLP temp record not reported.} \]

\[ \text{Rescaled to 1800 by N.S. 29.01.3195.} \]

\[ \text{(will work when thermocouple connected).} \]
Temperature Calibration 1/3/95

C.P. to 210 mPa
Control on bottom, tripping T/C.

1st profile at 1200 sec on control T/C to check precision record.

\[
\begin{array}{c|c|c|c|c|c}
T & A & V & P & ADJ. & \text{Power} \\
\hline
1700^\circ & & & & & \\
1700^\circ & & & & & \\
1200^\circ & & & & & \\
\end{array}
\]

On return, calib. T/C reading 1812 & 415 mPa.

No2 reading 1812 & 415 before failure
Jacket melted off at top & bottom but not middle of specimen. T/C lost

New Dummy Assembly

<table>
<thead>
<tr>
<th>PS Z</th>
<th>30.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al2O3</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>43</td>
</tr>
<tr>
<td>PS Z</td>
<td>30.25</td>
</tr>
</tbody>
</table>
Jumping test on AICS, need to throw off/on to reestablish.
Check on actuator switching:
Actuator switched on (wheel disconnected), jumps up 0.05 KN on AD off
10 mm on switching on actuator after initialization
0.07 (wheel active)

On these programs, go into TP procedure with actuator off & then def AD control program; AD jumps down 10.1 mm on switching on actuator after initialization
Repeated: Pos. = 31.3
(31.26)
SP comes up 31.24, 31.27
On switching on, SP remains same but actuator jumps down 0.1
On TSCR, Pos. is generally a bit below SP at this stage.

But when I stopped & went back to TSCR & re-activated the wheel, the POS & SP readings were fairly close.

Switched off PICS; all pens on recorder down to zero.
On again — pens came back OK, incl 485.
MAC is turned on but not running a program.

IF trace on recorder very clean while running J furnace.
New calib thermocouple & new calib assembly (see 1/3/95).

Frank had to lap out boxes of alumina during spec parts to get T/C to go through. Latest T/C testing on oversized 9 boxes of Al2O3 tubes not eccentric.

During pumping, controller on ③ temp on Eurotherm shows 472 K. When SP is 1600 K but OP is 32.4 — why not peaking while SP so much lower than T?

Pumped to 2.35 mPa.

Furnace settings were 775, 350, 950.
changed to 800, 365, 1000.

Still can't get furnace to self-tune. Turned off SAT & tried to ST — does not accept, & AT beacon does not light up. But beacon does light up when AT is selected & activated.

Profile ③ SP 730 K, Spec T = 1030 K & P = 259 mPa.
with settings 800/365/1000 — peaked at ~ 885 10.

② Try 750/340/1000 much better.
③ 730/300/1000 good - flatness. Somewhat different.
④ 730/250/1000 " " " a little better.
⑤ 730/200/1000

Setting T A X BV P SP = 47%

T 730 750 10.2 14.9 152
C 760 709 3.7 11.9 44 511 0.67 w/K
B 1060 731 13.2 23 315

Spec temp 1040 K
AD - flat

Temp: 1635 min

1040 K

CP

1 min 10 min

repeat 3 times

2611 Pa

The CP steps took place downward instead of upwards, but finished up down.

The initializing must have called for the up level first or something?
Tried effect of fluctuating pressure & stepping temp.

On stepping down 10 MPa in CP, spec. temp stayed at 1038

Ramped up in temp OK. Spec. was ~ 1145?
Ramped back to 750 after a couple minutes or so, T5 = 741
Tspec = 1025, climbing v slowly.

Looking at figures in IR: readings when furnace switched on/off — about 6-7 to 0-4 kN
Stress disappeared when furnace power on
not depend on furnace current (maybe sometimes)

5:20 pm

Started new program to ramp T up from MAC
by 150 K, held, then another 150 K, &
hold 67.5 h in each step, total 2 hrs.
Should go to about 650 K, 258 MPa,
holding automatically.

8:10 pm

Profile

<table>
<thead>
<tr>
<th>T</th>
<th>730</th>
<th>656</th>
<th>98</th>
<th>12</th>
<th>118</th>
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<tbody>
<tr>
<td>C</td>
<td>200</td>
<td>636</td>
<td>40</td>
<td>10</td>
<td>392</td>
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<tr>
<td>B</td>
<td>1000</td>
<td>640</td>
<td>13.0</td>
<td>18</td>
<td>234</td>
</tr>
</tbody>
</table>

Spec temp 895 K
Needs a bit for on top & cas in centz, say 760/150/1000.

Switched to SP 640 & 895 K on T/C 7 Botten
Then ramped up to SP 730 K on T/C 7 Botten
Profile 1: 50

Setting: T, A, V, P

- OP = 45%

<table>
<thead>
<tr>
<th>T</th>
<th>730</th>
<th>745</th>
<th>10.2</th>
<th>13.3</th>
<th>13.6</th>
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<tr>
<td>c</td>
<td>200</td>
<td>769</td>
<td>3.7</td>
<td>13.3</td>
<td>49.3</td>
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<tr>
<td>B</td>
<td>1800</td>
<td>730</td>
<td>13.6</td>
<td>23</td>
<td>313</td>
</tr>
</tbody>
</table>

Dipped + 5 KPa — no effect on spec. T; produced short ±2 K fluctuation at each of T/C.

Pumped up again: +2 K, then -11 K, then +1 K in ~ 2 min. Then steady. No effect on spec. T/C (±1 K).

Put on MAC program 9 pm.

Now on last stack of program to lift — ran OK.

Profile 8: 820 K for spec T = 1160 K

Setting: T, A, V, P

- OP = 52%

<table>
<thead>
<tr>
<th>T</th>
<th>730</th>
<th>820</th>
<th>10.4</th>
<th>17.5</th>
<th>18.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>200</td>
<td>767</td>
<td>3.5</td>
<td>13.3</td>
<td>57</td>
</tr>
<tr>
<td>B</td>
<td>1800</td>
<td>820</td>
<td>14.0</td>
<td>26.5</td>
<td>371</td>
</tr>
</tbody>
</table>

Needs a bit more on T & C, say 760, 23.0

Changed to SP = 950 K. 

Pumped C = 760 → C = 230

Dip in middle, boost C = 300, drop T = 730

Now power oscillating fairly widely, 42 → 69

Profile 9: 950 K for spec T = 1450 K

Setting: T, A, V, P

- OP = 50%

<table>
<thead>
<tr>
<th>T</th>
<th>750</th>
<th>1023/4</th>
<th>10.5</th>
<th>~22</th>
<th>231</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>530</td>
<td>956/7</td>
<td>4.6</td>
<td>23</td>
<td>106</td>
</tr>
<tr>
<td>B</td>
<td>1800</td>
<td>950+3</td>
<td>13.3</td>
<td>232</td>
<td>313</td>
</tr>
</tbody>
</table>

Length 740 / 530 / 1800 better. They may be an effect of bottom drops saturation at peak of move cycle.
When first turn on wheel after long period of non-use, very sluggish upwards.

Disconnected Terry from PICS to check whether 5F available—it is not.
Reconnected—but keep no longer being polled.

TP contact overshoot to 10 kN
Profile (10) \( 8 \theta = 980 \) cycling 972-982 \( \text{rpm spee} \ T = 1470 \text{K} \)

- Setting \( T = \frac{A}{10} \)
- \( T = 710 \text{ K} \)
- \( C = 986/7 \)
- \( B = 1000 \)

Initial load - 4 kN at \( TP = 33.2 \)

Makes very little difference to profile

 Went to phone - came back 4 bottom current 220, \( OP = 100\% \), steady, \( T \) \( \Theta \) \( \sim 1200 \text{ K} \)

Pressure still 298 MPa,
Cut power & turned off pump control
There was a new peak of about 4 kN extra, indicating an increase in temp of then fell again.

12.15pm
Put on TP window to hold on TP.
3.40pm - been holding fairly well, very little activity on actuator (only one step).

Down to 100 \( \text{MPa} \) - checked bottom winding: 166\( \text{K} \)
Other windings 9 T/C's \( 18 \text{K} \).

Calib T/C is stuck.

Dismantled: Jacket melt opposite top winding; presumed bottom winding failed & owing to controlling on it. The power went to 100\% & pushed up the temp at top, again to 1200 K (certain melt) as for previous jacket melting. Why the 240 K reading on bottom T/C?
All other resistances were normal.
CP Meters alartns

1. Used for need. Al lo off Al hy 1.0 Al no
   Al hi 600 Al tt 0

2. Used for deoholls A2 lo off A2 hi 1.6 A2 hi set to 30 A2 tt 0

Dund 0.1
Dept 0.1
3
50 IV 0 now
Postmortem on Furnace 012

There were minor cracks in the inner, upper PSZ felts; cirulators. The outer & lower inner PSZ were OK.

Lower winding was fused in two areas: in one case, near top. There had been an arc or something across two windings, giving a ball of melt at each end and a band of Al2O3 between. In the other case there was a small local blob of melt.

There was a fair amount of carbon burned, although not nearly more than usual. The SALL insulation was melted out opposite the melt bed in good shape over the remaining windings.

Circl & upper windings looked OK.

There was minor deterioration of the PSZ at the bottom end of the upper felt, inner pieces, suggesting that the SALL might be better extended upwards another 5 mm.
Check on furnace / no interaction
The TLC indicates an additional ~0.5 mV on the W&W chart when the furnace is on. I tried the following tests with the furnace absent (turning off the current in the windings did not seem to affect the voltage effect the other day).

With furnace off, TLC meter indicates ~0.4
  PICS screen  ~0.09 / 0.14
  W&W          ~0.03 / 0.4

Switched on furnace:
  TLC           ~0.1
  PICS          +0.19
  W&W           ~0.1 / 0.1

Axial actuator on:
  TLC           ~0.2
  PICS          +0.09 / 0.14
  W&W           ~0.2 / 0.1

Axial actuator off — no change.

Furnace off:
  TLC           ~0.5
  PICS          ~0.14
  W&W           ~0.4 / 0.3

Furnace on:
  TLC           ~0.2
  PICS          0.14
  W&W           4.975 V

Alan found that the effect can be eliminated by grounding the shield on the lead coming into the preamplifier box from the AD board. Can also get rid of it by earthing the ground on the AD board.
Touchpoint at zero pressure = 37.0

Reset bottom current limit.

Went to 11kN on TPT at 3.000 m/s⁻¹

Started at 3.25 pm.

Set free-dippl on MAC screen, -40 to +40 kN, -5 to +5 mm
- no dippl visible

AD PID = 42/30/0
IF 30/22/0
Test on Flapple - Compression / extension

Had a lot of trouble setting up:
1) no fresh 217 30mm id O-rings found
2) O-ring compressing nut eccentric - had to reduce it on one side of put on leads
3) O-ring compressed washer too thick - put in an extra small factor O-ring as well had to put it on outside
4) Miter ring in plug too small in id piston assembly did not go through - polished onto id until slipped on piston easily.

Assembly of steel pistons w Carrara marble speculum.
Flushed twice to 10^4 Pa
Some jumpiness on 1cc at end of second flush, put on 37^4 Pa. T of - in convect 377

Set furnace settings at 750/200/1000
P t ~ 1 hr, spec T = 917 K. Dec to atm at 658 K

Next morning: Program completed.
1cc record in extension still same sign as compression
Thc sticks at ~ 1.5
Otherwise OK.
Tech was on limits.  Back to Returned; Normal
Adv on AD.  Then pushed operate — Wheel
activated but screen frozen; all figures off
& no setpoint.  Could not wake up by any
changes of screen.

Switched off & rebooted again,

happened once before; brought George in but
didn't make a note.

Too high P — dead response
Very low — oversensitive
I & D very important for steady temps.  Very small
I makes places oversensitive.
14 C in extension
Checked with extensible load at 300 mV.
The meter reads positive in extension.

Went into CONF /1 CONF I checked on C1, C10
All except C2, which I changed to 0210.
Checked again — St. OK.

Put back ETH MIT card. Now St. works!
I had at one time turned off RCS & disconnected
the lead without success.

Put furnace on ramp to 400 K SP7.
Self-time not work.

Turned furnace off, pulled card out & put back.
Now St. works.
Put power on & took to SP 4007, put on self-time — it showed A-T & flashed SP.
Later, flashing A-T.
Checked ETH in INST menu = 1.5

Gave another St. Now 1.4 = Pb.
A third St. Now Pb = 1.5

Talked to Andy at Eurotherm. He thinks it is a problem
of the boards contacting improperly when pushed into
the case. If too far, no good; there is a spacer to
keep right distance.

Recommends keeping a record of Pb. They
set them at 1/360/60.
ILC in extension (ctd)

We seem to lack a reference for phasing — all changed connections to Schenck unit.

New connection: Desired to record the change of sign but wrong polarity & about 1/10 of value. Think I broke the specimen.

7/3/95

Installed steel extension assembly.

Bubbles at 113 at 300 MPa.

Ran manually in ext & compression — ILC made no sense — at first gave same, but reversed sense of signal for both comp & extension, but did not build up — ie somehow compensated, as Han suggested last night.

Reconnected as previously but with a capacitor linking excite to output — output now 12.9V DC regardless of gas set-up on Schenck. Cut out capacitor — now get normal yes. ILC lead connected to 8.

Changed ILC lead into 8

Reverses the sign of the ILC signal on meter etc but still in same direction to the compression & extension. Double gain.

Now connect 8 to ground, leave 6 to ILC. Still same as previous trial but -5.7 greading took it off - still -89

Linked 8 to excite from 3 — 14V offset.
In setting up PP demand signal, current values & limits were shown as "inf". 

10 cycles

double complete = 5 mm
Dismantled - took out furnace & bottom plug in order to mount port fluid equipment.

Found small pick-up on loadcell body in guide in bottom plug. Tapped out guide bore a bit.

Reassembled piston diameters & holes:

<table>
<thead>
<tr>
<th>Component</th>
<th>Diameter</th>
<th>Bore</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load cell piston</td>
<td>29.960</td>
<td>30.047</td>
<td>0.087</td>
</tr>
<tr>
<td>Comp. piston head</td>
<td>42.425</td>
<td>(measured earlier)</td>
<td></td>
</tr>
<tr>
<td>Comp. piston</td>
<td>29.960</td>
<td>30.047</td>
<td>0.087</td>
</tr>
</tbody>
</table>

in view of high friction at 500 lbf (380 lbf on 86)

Reassembled with upstream & downstream port fluid attachments.

Setup program - couldn't get it to go in % of limit info! - see left.

Evening

Alan installed Mr. Schlumberger demodulator in place of the Schaefer.

Tried compressor - extension at 300 lbf - new TLC reversers sign. Set gain approximately.

Set zero on Schlumberger using fluke on TP on Norm's distribution board. Assumed bridge still balanced.

Setup for block - 1mm amplitude (should set torque after 0.4 mm)

TP 32.75 Set at 32.4

Ram AD cycles, 6mm amplitude, TP 33.5 Set at 33.6

Put in spring - 6mm amplitude.

Determined from graph @ 8/3/95 that the TLC
is reading now & needs to be increased by a factor of 1.207.

Set 70.7 (zero is -0.2) to total ~ 40.9

40.9 x 1.207 = 49.36 - 0.2 = 49.2

Reset to this on gain on RS board.

Run another cycle.
Bottom plug cap holes are 32 PCD.
Tool is 35 PCD.

Zurich machine should be bigger.

Explain in manual re zero adj — V & I
setting.

Procedure for PP testing — correction p23

1F meter now shows 2.0 — is this due to different coupling to earth with the PP end in place.
Testing Core Pressure System

Assembled with sandstone specimen.
Downstream transducer connected to downstream isolate valve.
200 MPa rupture disk fitted

Both p.p. meters set up 4-20 mA 4 = 0 20 = 500
Zeroed CP, DPP, OPP on AIC meter (I) & ACS (V).

F
Contact 36.8 ~ 30 - gave force + 0.2 kN or so
At POS 37.0 the force seemed to be ~ 2kN.
But leaking from DPP

Tried again - 1kN load.

DPP goes down very gradually - must have considerable resistance in 1/16" tubing to interconnect meter

Leaking somewhere in DPP area
Transport rate along the 1/16" tubing now very small; 3 psi holding in pressure gauge block even when interconnect open while testing the specimen.

Zero of DPP meter has drifted up to 0.6. At 0.15 psi it was 0.5.

If zero still 19 with the blank central pot plug in RCC base.
Acide EHC valid

OK.

Axial actuator

PID's set by George

AD

1F

EF

Pro fluid

PD 100 / 0 / 0

PP 100 / 0 / 0

Step on chart at fast rate compared to update rate

PID Settings

2019/4/8
George changed some resistors etc in PICS to improve actuator response. Commented on discrepancy between ILC & ELC — need to check back on this. PID settings now different.

George had a preliminary go: $P = 50, I = 20, D = 10$ of ADS.

Steps consist of update rate.

Ran calib on ILC again. Reading mix may be due to being at 0 MPa (see earlier).

ELC seems to read high. Checked on 10000 lb = 31.1 kN (zero - 0.2)
At 7000 lb, EF HTC meter reads 31.4 and PICS 31.5. So problem is in ILC software.

11/3/95

George working on PICS PID’s & power amplifier set up overnight. Changed some hardware & set the following PID’s:

- AD - $P = 400, I = 20, D = 200$
- 1C - $P = 100, 20, 100$
- EC - $P = 100, 20, 100$

Pipe fluid system:

- PD - $P = 400, I = 50, D = 100$
- PG - $P = 100, I = 0, D = 0$

Howth: The ILC was reading about same as ELC overnight but is noisy. When I moved the cards a little, it changed again. Have to wait until cards are back in their box.
After 12C preamp put in box, noise gone again. Calib approx OK.

Doorbell relay now OK with new changeover relay.

Tried to set up pce pressure:
1) Leaks at top - seemed to have to do with the scale on jacket
2) then got a leak at seal into load cell base

Gave up at this point & put block in for George.
IF PID new 60/10/100
George he likes P = 60 would be OK.

On desktop, PICS Boot UTL folder.

Furnace PID = 1.5/29/215

T/C 2 reading RT on cal T/C
Tom George been in during night, presumably until about midnight because records been running on experiment & ELC upper limit tripped about 5 hours ago at 99.6 K.

IEC now reading 60 when ELC reads 78, so it seems to have tripped into low reading mode again, which yesterday I attributed to the pre-amplifier being unshielded; not the case now. Zero is 1.7.

Also the machine had gone into oscillation a bit before switching off. It was running in IF control on the block. Yesterday it was 1.8 when I left, although when working OK the previous evening.

Loaded H3/ly tempeal at assembly. T/P at 0.1Pa = 40.5
Card back to 34.5.
Flashed twice.
Pumped to 1100 mPa. Forgot to connect furnace.
Back to 30 mPa as that
Put furnace on SP7 = 600 & ramped up.
Pumped to 200 mPa & later to 300 mPa.
Furnace taking ~ 89% OP at SP7 = 600 K !
Forgot to put inner sleeve on.
Down in pressure & put inner sleeve on.
Up in P & T again.
At pressure, IF zero now 0.0
Look at the drawing and note the dimensions:

**Touch 40.4**

40.7 15-20 kN

**Four P to 2.0**

TP 40.4

TP 40.4

580/480/00.
SP(5) = 600

<table>
<thead>
<tr>
<th>Profile (1)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>750/180/1000</td>
<td>875</td>
<td>915</td>
<td>928</td>
<td>931</td>
<td>933</td>
<td>934</td>
<td>938</td>
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<tr>
<td>680/190/1000</td>
<td>875</td>
<td>915</td>
<td>929</td>
<td>935</td>
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<tr>
<td>640/170/1000</td>
<td>875</td>
<td>915</td>
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<tr>
<td>560/160/1000</td>
<td>874</td>
<td>909</td>
<td>920</td>
<td>921</td>
<td>920</td>
<td>916</td>
<td>909</td>
</tr>
<tr>
<td>580/150/1000</td>
<td>871</td>
<td>902</td>
<td>910</td>
<td>916</td>
<td>909</td>
<td>905</td>
<td>905</td>
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<tr>
<td>620/100/1000</td>
<td>848</td>
<td>877</td>
<td>881</td>
<td>881</td>
<td>881</td>
<td>881</td>
<td>870</td>
</tr>
<tr>
<td>650/0/1000</td>
<td>872</td>
<td>876</td>
<td>878</td>
<td>875</td>
<td>876</td>
<td>876</td>
<td>875</td>
</tr>
</tbody>
</table>

Profile (1) SP(7) = 600  (6) = 565  (5) = 656  OP = 63.5

Setting: T A V P

Initial:

<table>
<thead>
<tr>
<th>T</th>
<th>6</th>
<th>6.5</th>
<th>10.7</th>
<th>13.5</th>
<th>14</th>
<th>(412)</th>
<th>0.68 W/K</th>
</tr>
</thead>
<tbody>
<tr>
<td>l</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(412)</td>
<td>0.68 W/K</td>
</tr>
</tbody>
</table>

B 1000 13.7 19.5 25.7

Now ramp to 800 K on SP(7)

Temp oscillating, meanwhile. Decrease P to 1.3; seemed to be worse, increased P to 2.0 — better.

Profile (2) SP(10) = 800

Setting: T A V P

Initial:

<table>
<thead>
<tr>
<th>T</th>
<th>615</th>
<th>932</th>
<th>18.0</th>
<th>300</th>
</tr>
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<tbody>
<tr>
<td>l</td>
<td>300</td>
<td>783</td>
<td>4.4</td>
<td>18</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>860</td>
<td>14.3</td>
<td>28</td>
</tr>
</tbody>
</table>

Spec T = 1230 K

OP not recorded
\[ y = 2.9 \quad x = 1.7 \quad b = 0.2 \quad \text{effective} \quad 3.3 \rightarrow 3.5 \]

Better 520

1000,
Ramp to 925 K on \( \theta \)

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>615</td>
<td>580</td>
<td>560</td>
<td>1000</td>
<td>1200</td>
<td>1300</td>
<td>1325</td>
</tr>
<tr>
<td>B</td>
<td>300</td>
<td>480</td>
<td>520</td>
<td>1000</td>
<td>1333</td>
<td>1395</td>
<td>1437</td>
</tr>
<tr>
<td>C</td>
<td>1381</td>
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<td>1423</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

Profile 3 \( \text{SRTD} = 925 \text{ K} \)

<table>
<thead>
<tr>
<th></th>
<th>71/72%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
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<tr>
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<td>360</td>
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<td></td>
<td>1094</td>
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<tr>
<td></td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>111</td>
</tr>
<tr>
<td>C</td>
<td>520</td>
</tr>
<tr>
<td></td>
<td>931</td>
</tr>
<tr>
<td></td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>90</td>
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<tr>
<td></td>
<td>682</td>
</tr>
<tr>
<td></td>
<td>0.58 W/K</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
</tr>
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<td></td>
<td>925</td>
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<td>14.8</td>
</tr>
<tr>
<td></td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>481</td>
</tr>
</tbody>
</table>

Spec \( T = 1445 \)
AD PID = 450/20/100

The actuator goes in
starts up & back
with the updates
turned back to 350/20/100

From these two runs (12/3/95 2 & 3) at 300 MPa,
the internal load cell is showing 11.51 kN/mm,
compared with spring constant 11.4 kN/mm — OK
within 1%.

The actual observations were:
0.0988 mm/kN uncorrected on spring
0.0119 mm/kN on steel block
0.0869 mm/kN corrected,
or 11.51 kN/mm.

Thus the apparatus distortion correction is 0.0119,
say 0.012 mm per kN.

3/95 calibration, after adjustment gives
0.1007 mm/kN uncorrected
0.0112 mm/kN on steel
0.0885 mm/kN tested adjusted
from pot-coded measurement
or 11.97 kN/mm.

Average of these two is 11.3.
Agrees with 11.4 within 1%.
Chicken LIC calibration
after it appears to have changed (could have
shifted the plate when extracting the pp.打架
Balanced bridge again
Zed at -31 now, so zeroed on the front pot.

Tried running calib runs.
Friction: 20 kN at low load, goes up to 30kN
or so at higher loads.
Did a couple calib runs at 300 MPa.

Then put in steel block 4 again cal at 300 MPa
During pumping up, IF signal ran 3.1, then
while steel pumping, it jumped to 1.5, later
up to 2.2 again
Touch 327
33.6 at 90 kN & 7
Noise on IF signal was 2.6, stopped just
before contact. No pumping, no furnace, actually
that running at the time. Pressure vessel had been
opened while pretty cold but block put in quite quickly
by closed up again.
\[ Z_{\text{ppd}} \]
\[ B = 7 \]
\[ 1 = 6 \]
\[ 1 - 5 = 2 \]
\[ p \]
\[ d \]
\[ r \]
\[ g \]
\[ u \]
\[ l \]
\[ c \]
Overnight HC steady but zero at 30 x 3.1
Put zeroing not en point back to 5; then zero is 0.1

Red Fluid System — Sandstone specimen
Still problems with seal at top.

Fed into the cone was not seating in the spigot piece
that goes into the top of the jacket — hazed not relieved &
building before cone seats. Relieved thread.

Previously established that the TP is 36.5
Act at 36.5 MPa.
Bottle pressure ~ 9 MPa
Put 5 MPa in PP system — OK now.
Gp up to 100 MPa.

CP UPF = 5.8
DPP = 5.1
PPRIS = 25.0

1062
5.9
5.2

Over PP 40 – 60 — sprung a leak.
17.8
16.8

Replaced coated metal ring by O-ring on downstream pro
pressor transducer.

Tightened ½” pipe into transducer block.
New holds 100 MPa.

CP UPF = 107  LPP = 103
136
107.3
150
107.9
300
109.4
300
115.0
118.9

Closed DP interferes.
120.0
120.3

115.3
115.5

Run 10 cycles on pp displacement control — OK
except for drift.
Zerks: UPP  LPP
  0.6  0.0

Zerker: UPP  LPP
  0.7  0.3

105 20  P = 73  7 MPa
905 30  66
POS 0 in
50 out

Software limit \( \approx 46 \)

71.3
30.2
Released pressure, pp first.
At low cp, bubbling at 6.

Dismantled spec assembly - looked OK.
Put together again with temp sleeve on it.
Pumped to 1001 kPa, then ran extensive
at CP UPT DPP
145 8:2 7:3 set in snesgaps
232 12:4 11:9
Still the same.

Took out & re-waxed spring tube ends.
Back. CP to 1001 kPa, up to ~ 1301 kPa.
With PP ~ 100, leaking up fairly fast.
Seemed to leak fast at PP ~ 50.

Took CP up to 3501 kPa

150
200

Turned out that argon interconnect valve

Changed 0 - 10V = 25 - 50
25 - 0

Now 50 is fully in
Volumeter POSITION is 0 fully out
50 fully in

There are no software limits on the volumeter.
- put in manual

1. PPD
2. P
3. UPD
4. AD
5. IF

Eurotherm idgn:
0004 in set
Poor Pressure & Control

We had the situation that the pressure went up when the
POS went down – the program did not like this for
running on pressure control. It was because the
DCDT circuit was set up with reading 50 when the
volumeter piston was fully out instead of
fully in.
Reversed the leads on the DCDT output to PCS and
to AIC meter. Now PCS reads increasing
pressure with increasing POS.

Tried another run on pp control.
Worked OK on pure pressure control with ~ 70 MPa
POS & 200 l/min sp 7 l/min amplitude, 3 min
period. No perceptible phase lag in Hawthorne SS.

Set up for definite run.
Went to 200 MPa

Left furnace ramping up to 800 on No 5 (top)
Th, which should give 1060 K spec temp.

7.30 am. Spec temp 1065 K
Moved sp to 1180 K for spec temp ~ 1550K
(~1280°C).

About 13 kHz if free had come on during the
night at POS 36.8. Turned back to 36.0; load
floor was 0.2, fraction ~ 12
7.55 am – reached sp temp. Pumped to 400 MPa &
jet on control.

At sp = 1180, we have now $C = 1029$
$\theta = 1039$
If temp connection broken, have to switch PICS off or again to restart communication.
Changed to settings 530/640/1800
Changed P on controller from 3.5 to 4.0

Started AD control def. run at 480/170°C
Look somewhere — can't see any bubbles — turned out that furnace had been turned off & it was cooling. AD did not reach setpoint.
The PICS/MAC had set setpoint in controller to 323 K at beginning of program.
React the furnace at SP(5) = 980.

Hold at ~1155 K at 980 SP(5) 378°C 170°C

Started program; it was for furnace was cooling ramp in 12 h — took ramp off because furnace ramped up to 1800 K & then on hold. Checked Table
for 905, 361, SP(5) = 1000.

On program; it said ramp up 280 K.

Put in manual ramp to 1180 K.
Repositioned to 36:1, fraction ~ 25 kN
Pressure 380.1 kPa.

Ramp reached 1181 K. Spec T = 1581 K. OP = 74%

<table>
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<tr>
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<th>T</th>
<th>A</th>
<th>V</th>
<th>P</th>
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Load-displ curve flattened out at about 5.5 kN.
Tried my own — at first tried on EF. Turned out to be lathes mostly.

Started again at 1F ~ 5.5 kN

Had to turn PID from 100/20/100 down; would not take any input when tried. Had to cut P down to step one. Then build P up again. Finished at P = 80, I = 0, D = 100.

Checked with TC at this stage; it would only go down to 0.5 POS — went all the way a little earlier & registered 1592 kN.

Fricción is about 24.7 kN

Reverse friction ~ 25.4 kN
Eurotherm setting for 0-10V according to Anil Batham

Go into instrument CONFIGURATION, pH calibration chapter
CONF = UCONF & CONF ORANGE & CAL, push left key
(vine key), scroll to CAL — probably ~ 18.8 to 20 mV for 4-20mA, read to zero.

[Shipped machine 15/3/95]
Installed in L19 ~ 30/3/95
As delivered:

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<tr>
<td>D</td>
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Pure pressure D
- P = 600
- I = 50
- D = 100

PICS problem
First came up saying unrecognized limit hit.
Checked all connections & transferred computer cable from modem to printer connection after checking in manual.

Still same limit, although now on switching on PICS it balks but does not show the limit message (reset is flanked out) until I go into limits & out again.
The AD setpoint can be moved either way by the wheel even though wheel not activated — ACTUALLY does move.

Tried downloading PICS parameters — still the same.
PICS does not accept CP SP.

Email from George to look at CP card etc — all OK, only CP signal on PICS seems a bit noisy.
George suggests checking no voltage or back planes — no description in manual wrt to power supplies.
Disconnected PIFS — no difference.

Voltage

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for pin:

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Eurolum. meter book

UPP TLC

Spec. TLC
Metal sheathed TLC.

UYCPLL - CG - 0.000.000 MPa

UYCPLL CG 000.000 MPa <CRLF>
On the DD board, back light continuous, front light flashing.
AD " " back light off, front flashing.
UT " " on, flashing.

CP meter reads -0.7 steadily.
2.000 - 1.96 to 2.051 = range of 545.
CP on TP on Name board reads -22.16 to 22.49 mV.
-1.55 mV 1.57 mV i.e. ± 0.02 mV.

Connected terminal to PICS.
Says: LIMIT HIT.

Control System: Confining pressure.
Channel name: Confining gauge.
Limit Hit: Lower Limit.

When tried to clear, it immediately came back.
Then asked for the limit:
*U'CPLC CG 0.43.57 MPa.
So then is evidently a CP lower limit (?) and it has got set on 43.57 MPa.
Tried to reset it will * UY CP & + CG + 000.001 MPa etc.
But could not get it to accept.

After George’s message about correcting the command set, we were able to insert a new lower limit of 0.000-0.000 MPa &
thus the limit could be cleared.
Now the problem with active wheel also disappeared.
Note:
1) Connection into Haskel gas booster was loose — must have shaken loose on trip
2) Oil connection from bleed solenoid valve to bleed leaked when "bleed" activated

1) Should change transf. setting to 220V
2) Read transducer for 0-10V

At beginning of 2/4/95, actuator was at 105.22; we moved it up to ~40 — was OK at that stage (still in PID 480/20/180).

After raising temp, gas pressure went to ~340 MPa. Switched to PLCs to control on intension — big oil squirt & pressure dropped to somewhere below 300. Pumped up again, got another squirt. Took control off.
2/4/95

First run:
- Furnace calcite spec. assembly in.
- Pumped up - blew 200 MPa rupture disk at ~180, replaced.

Took furnace up on 5Ps = 790 K.
- Center winding not working.
- Upper TC and Cal TC not working.

Ramp to 720 K 5Ps

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<th>P</th>
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459 W 0-75 W/K

Specific temp = 886 K

When tried to move actuator, it oscillated badly, had to cut PID back to 15/0/10. Problem with oil spray??

Voltmeter shows 10 V when switched off.
1) MAC: could not communicate with PICS.
2) Tried to PICS boot
3) Settings in PICS not changed.
First: MAC says PICS not here; tried to reboot PICS.
Ongoing through PICS Boot procedure, after a number of false starts, got it to work apparently, but PID parameters in PICS were not updated, & when quit was pressed at end, it did not quit.

Question: is the problem with the oscillations of the AD motor PID settings related to the inability to reset the PID's from the PICS Boot facility?

If one pushes quit once, it comes back again.
Push quit first time — it brings up buttons on top of screen. 2nd one — press grey & sticks. Can close the windows.
This PICS Boot does not reset or PID either.

Presumably MAC messages to PICS are not getting through.
Why?

Testing Motor Control again
Still some oscillation at PID = 30/0/0. drove up to 20 KN, reduced to small value.
Put in 400/120/100. — now wild oscillation as before; reduced to 30/0/0 — same or slight as for other amplifiers.
So amplifier seems OK — only backplane could have changed when oil leak occurred.

Explored PID settings with spring: 10/20/0 seem best.
Set point is showing ~1 unit value variation.
Alternative PSZ supply:
O'Keefe Ceramics Inc (Pres. Brian M. O'Keefe)
845 Research Drive
Woodland Park CO 80863
Tel (719) 687 0888
Fax (719) 687 0889

For ϕ18.43 x 30.00 long x ϕ3 bore, beveled edges
2 pieces US$ #125
4 pieces USD 100
3/9/95
8-10 wks
Called Zircon 4
Called Zircon L
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Attempts to connect MAC.

4/4/95
Using $P = 10$

$I = 10$

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### 300 MPa

**Checking with solid block**

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After George's 5/4/95 message.

* LM TYPE? gave no limit. XXXXXX. OK.
* AC AL RTG? -0.488 rpm. OK
* VC CP RTG not valid.
* VC CPB? 4.999. OK.

LED on on PP board indicates a limit.
* LM STAT UP DG LL gives 183.35 MPa.
   UL 49377 MPa.

Act. LL DG at 800-800 MPa.
* AC UP UL DG +493.77 MPa.
* AC UP LL DG +480000-000 MPa. ←
* AC UP UL PD +0.71.90 mm.
* AC UP LL PD +0.00-00 mm.
* AC DP, CP (PG? no answer.)

Rebooted PICS.

Limit light on PP board now out.
After message from Peter & Norm, put 960 MHz cable into modem port 1 — worked immediately. I think we had tried this before but not since clearing the extra limit on PP board.

Now can’t get PICBoot to work.

Tried touch point — wild oscillation on “factory” PID setting of 80/10/100; still at 80/10/0 but quiet at 10/20/0
On 15/0, it is oscillating mildly
15 low
12 OK? But can’t be preferred — still 10.
10 still 10.
8 steady
Peter I — took 10 OK (“factory” setting).

Run in AD mode with PID 10/20/0 on spring (controlling 8K)

Then run in IF mode with PID 8/10/0; got stuck at 20 [KN]; incr PID to 15/10/0; now OK.

On using the touchpoint procedure, actuator tends to overshot — further evidence of a problem in TG mode.

Repeat at pressure of 300 [Psi] Had to increase PID to 8/25/0 to get to 50 [KN]; then cut back to I = 20 to avoid cycling on EF. On unloading, gets unstable again; still ok at 8/10/0 PID. On second cycle, incr PID to 12.15/0. At 22 [KN], PID → 15/15/0; controlling better than on 8/25/0
Shipsome Zircon ARA-2 ppm

\[ Y < 0.01 \]
\[ Y < 0.1 \]

\[ \alpha \]
\[ 0.9 \]

1F

5 m

30

PP

39 m

10 cycles

5 min

30 sec period

Ampl 5

30 sec period

Ampl 10

After quitting program, TSCF frozen. Can still select function, but all values read in are zero. Came back on line during lunch.

Original PID

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<td>20</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
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</table>

Furnace

\[ P = 4.0 \]
\[ i = 12.9 \]
\[ d = 21.5 \]
New a run on spring in AD control, PID = 10/20/0 worked up to 94.7 kN, as far as load went.

Port Pressure Test

Loaded up 10x 100, 60x 50, 60x 60, cut in steel jacket with steel picture.  7P = 32.6 at 0.41 kPa.

Check CP at 14 MPa ~ OK.

Test CP to 86 MPa, then let in PP to 57 MPa, CP to 309.  After equalizing to PP at 280

Now CP = 308  VP = 191.5  DP = 182.1 (difficult).  Shifted PD from 24 -> 25, VP = 194.7  DP = 186.1.

Initiated torque, at 11 kN - overshoot 0.6 ~ 22 kN & back, oscillating a bit, cut back PID to 618/10, still see a bit.

Power Pressure PG  T = 100, I = 20, D = 100.

When quit computer program, EF stopped fluctuating while IC is still showing on.

Could not see 1.1% fluctuation or oscillation.

Set 2 -> UPP
3 -> PPD

Ran on PPD & PPG for various cycles to check PID P. Original PID seems ok on PD control but need P = 1600 for PG control.

Dropped CP to 30 & PP to 15, connected furnace & pumped up. Put furnace on ramp to 620K(5)

When 5 = 622, 7 = 640  For spec T = ~ 830K

Setting Amps  V  P  OP = 0.32  0.69 W/K
 Fu  12.2  11  112
 Fu  12.2  1112
 Fu  12.2  11

3 1600  13.6  20  27

3 = 620, 6 = 847 7 = 640
Talk on Analog Devices

1. With transducer connected, signal is 12.44 mV.
2. Disconnect transducer.
"P = 1600" on PG control of PP 8K at 60s cycle.

8/4/95

Looked at AL board; DS1 selector seemed to be in correct position (see George & Norm's letter).

- Confining pressure: Input: Readi.
  - 10.94 mV
  - 0.00 mV
  - 10.94 mV

- Supply: 10.109

- Span: 7.000 - 7.085
  - 7.000
  - 7.085

\[ \frac{10 \text{ V input}}{7.000 \text{ MPa}} = \frac{7.085 \text{ mV}}{7.900 \text{ mV}} \text{ for } 10 \text{ mV}, \text{ at } 500 \text{ MPa}, \text{ calib. is } 7.815 \text{ mV for } 10 \text{ V} \]

- Headroom: 10.5087
  - 0.88
  - 0.88
  - 0.88

- Span: 515.6
  - 498.12
  - 498.12

So we set the AIC & PICS meters to zero at 0V 500 at 7.868mV with transducer disconnected.

Reconnected CP transducer - takes a while to warm up & zero drifts upwards.
Got a limit signal on AD LL when actually on DFS LL.
External Load Cell

Disconnected meter
Connected voltage divider

Set zero on PIC5 and AIC with zero excitation voltage
For 100 kN, read 2.9214 mV/V
Actual excitation = 10.1164 mV in = 29.55 mV
Calibrate at 75 kN: require 22.16 mV
Could not get it on scale.

Changed calibrating resistors on back of conditioning unit, back
from 470 to 580.5 Ω set.
Set zero span at 75 kN level.

Put connected load cell - zero now 16.7, too much to adjust in conditioning unit.

Put offset 9.9 in AIC meter using USER range, then
changing back to 0-20 mA.

Upper Core Pressure

Excitation voltage = 10.1164 V, 10.107 V
Disconnected transducer
Connected voltage divider
3.430
Calibrate at 80% scale is 0.799 x 2.740 mV/V = 2.274 mV/

mv for 2.738 mV for 10.1164 V excitation.

Connecting the voltage divider to conditioning unit
pulls the voltage from ~220 mV input to ~1620 mV.
Why should it be so loaded down? Is not in case of C57?

With zero input, set input = 23.13.
Then AIC meter reads 341.5 mV PICS 338, but this
makes no sense since it should be ~680 and was not so
different from CP calib yesterfae.
Effects in PICS:

<table>
<thead>
<tr>
<th></th>
<th>AL AD</th>
<th>AL IC</th>
<th>AL EC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.090</td>
<td>-0.170</td>
<td>-13.010</td>
</tr>
</tbody>
</table>

| VY CP CG | 0.000 |
| PP UG    | 0.800 |
| PD       | 0.000 |
Lower P&G gauge

Excitation voltage $= 10.112 \text{ V}$

Calibrating scale is $0.799 \times 2.667 = 2.1282 \text{ mV per V for } V$

$= 2.146 \text{ mV for } 10.112 \text{ V exc. for } 100 \text{ MPa}$

$21.84 \text{ mV } \times 300 \text{ MPa } = 21.84 \times 300 = 6552 \text{ MPa}$

With input at 2.91, reading $A1C = 3.056 \text{ mV, PICS } = 302.6$.

Set $A1C$ meter & PICS to 300.

Checked zero - OK.

Pumped up to 300 MPa with UG, DG & CG connected.

CG = 99.8
UG = 101.6
DG = 101.7

At 200 MPa:

202.5
208.6
206.9
200
206.2
204.6

Air pressure:

-0.2
0.3
-0.1

AD POS Calib using calipers on stamp:

<table>
<thead>
<tr>
<th>A1C</th>
<th>PICS</th>
<th>Caliper</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.11</td>
<td>37.11</td>
<td>139.36</td>
</tr>
<tr>
<td>48.00</td>
<td>48.01</td>
<td>128.55</td>
</tr>
<tr>
<td>40.1</td>
<td>40.14</td>
<td>136.37</td>
</tr>
<tr>
<td>30.15</td>
<td>30.15</td>
<td>165.90</td>
</tr>
<tr>
<td>19.9</td>
<td>20.07</td>
<td>155.66</td>
</tr>
<tr>
<td>9.7</td>
<td>9.91</td>
<td>165.49</td>
</tr>
<tr>
<td>6.7</td>
<td>6.84</td>
<td>168.93</td>
</tr>
</tbody>
</table>

Pre-adjusted range to be 50.8 on PICS $(+0.3)$ offset

$0V \text{ zero } = 25.4 \text{ on } PICS$,

$10V \text{ } = 50.8 \text{ on } A1C$.
Check again:

<table>
<thead>
<tr>
<th>PICS</th>
<th>AIC</th>
<th>Caliper</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.79</td>
<td>6.8</td>
<td>168.88</td>
</tr>
<tr>
<td>10.30</td>
<td>10.3</td>
<td>165.19</td>
</tr>
<tr>
<td>20.18</td>
<td>20.2</td>
<td>155.70</td>
</tr>
<tr>
<td>29.97</td>
<td>30.1</td>
<td>146.46</td>
</tr>
<tr>
<td>39.99</td>
<td>40.1</td>
<td>137.09</td>
</tr>
<tr>
<td>47.97</td>
<td>48.2</td>
<td>129.18</td>
</tr>
</tbody>
</table>

Rescaled to 49.0

<table>
<thead>
<tr>
<th>PICS</th>
<th>AIC</th>
<th>Caliper</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.51</td>
<td>46.5</td>
<td>129.18</td>
</tr>
<tr>
<td>40.15</td>
<td>40.1</td>
<td>135.61</td>
</tr>
<tr>
<td>30.20</td>
<td>30.1</td>
<td>145.36</td>
</tr>
<tr>
<td>19.85</td>
<td>19.7</td>
<td>155.58</td>
</tr>
<tr>
<td>10.19</td>
<td>10.0</td>
<td>165.18</td>
</tr>
<tr>
<td>7.80</td>
<td>8.8</td>
<td>Within 0.2% 165.18</td>
</tr>
</tbody>
</table>

Slope for PICS slightly different from that for AIC

Net scale 48.9 in PICS, 49.0 in AIC

Difficulty getting pore pressure connection out of AIC. Worked the 6" tube down a bit — better.
TSK stirring SP 300 but pump went beyond so turned out hydrogen was 12.5% instead to 1%

Furnace PID = 4.0/129/21.5

Details in notes:
- 10.12.19
- 21.10.19
- 12.8.19
- 28.9.19
- 19.8.19
- 8.5.19
- 4.5.19
- 20.3.

Museum of Science:
- 12/20
- 18/19
- 19/19
- 21/19
- 28/19
- 29/19
- 1/20
- 10/20
- 18/20
- 9/20
Temp Calibration

120°C = 3.3

TP @ 0.1MPa = 39.4

300 MPa

Controller on

SP = 600

635/0/1000:

773 779 778 775 769 763 747 745 743

600/0/1000:

773 778 777 775 771 764 750 747 743

730/1/1000:

620 638 770 771 771 770 764 764 764

730/0/1000:

762 770 771 771 771 770 764 764 764

Spec temp 771 K

Control SP = 600 K

West to SP = 750 Am ~ 970

Reduced P ~ 2.8

T = 45°

PB = 752 ~ 745 = 7 K

No need P = 4.7

L = 22.5

D = 5.4

Try again. Turn off i & d; put P = 3.0

P = 1.5, 1.0, 0.8, 0.4, 0.2, 0.1

0.1 T = 9

Temp land 1K(-)

Suggest P = 0.2

I = 4.5

D = 1

Augmentation you make

Try P = 3.0

L = 20

D = 5

Controller is

SP = 750
Drastic effect - cut off
When $\Delta T = +5$, 100%
When $\Delta T = -5$

- Set $C_6H_4$CB = 10
- Set $C_6H_5$CB = 5
- Set $C_6H_4$CB = 5, 10
- Set $C_6H_5$CB = 5
- Set $C_6H_4$CB = 5

PID 4.0 120 30
not holding SP well

$\rightarrow$ PID 4.0 150 36
$\rightarrow$ PID 3.0 140 36
$\rightarrow$ PID 3.0 100 25
$\rightarrow$ PID 3.0 80 20

Changed to controller 1
PID 4.0 180 25

0.25 = 0.92 0.25

$1 = b_1$, $a_2 = 1$, $a_0 = 1$
<table>
<thead>
<tr>
<th>Setting</th>
<th>T</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>640</td>
<td>750</td>
<td>10.5</td>
<td>12.5</td>
<td>163</td>
</tr>
<tr>
<td>C</td>
<td>200</td>
<td>649</td>
<td>3.8</td>
<td>11.5</td>
<td>44</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>657</td>
<td>14.0</td>
<td>21.2</td>
<td>297</td>
</tr>
</tbody>
</table>

Spec $T = 968$  Control $SP(3) = 750$

<table>
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<th>T</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>630</td>
<td>900</td>
<td>10.2</td>
<td>17.5</td>
<td>179</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>776</td>
<td>4.8</td>
<td>18.8</td>
<td>90</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>756</td>
<td>14.0</td>
<td>25.5</td>
<td>357</td>
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</table>

Spec $T = 1163$  Control $SP(3) = 900$

New $SP(5) = 1050$

<table>
<thead>
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<th>T</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>630</td>
<td>900</td>
<td>10.2</td>
<td>17.5</td>
<td>179</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>776</td>
<td>4.8</td>
<td>18.8</td>
<td>90</td>
</tr>
</tbody>
</table>

New $SP(7) = 860$

<table>
<thead>
<tr>
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<th>A</th>
<th>V</th>
<th>P</th>
<th>OP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>670</td>
<td>1114</td>
<td>10.7</td>
<td>23.5</td>
<td>251</td>
</tr>
<tr>
<td>C</td>
<td>685</td>
<td>941</td>
<td>5.4</td>
<td>30</td>
<td>162</td>
</tr>
</tbody>
</table>

Spec $T = 1486$  Control $SP(7) = 860$

Spec $T = 981$  Control $SP(7) = 657$

Became unstable
Temp Calib (until) All at 300 MPa.

Lift machine overnight at SP0 = 1400 but furnace had switched off (water pressure? still enough to start but then went off again, I opened tap some more)

Put on SP0 = 400 K 244 MPa.

10/6

profile 6 7 8 9 10 11 12
670/685/1000 526 536 501 608 607 604 592
Setting T A V P 0 P 0.2-3% 

Temp 670 522 7.5 ~2?
C 655 465 7-2 13
B 1000 400 9.5 ~4?
Spice T = 609 Control SP0 = 400 ; not flat

Now repeat 968 K run but using SP0 = 657 K.

Reached SP ~ 8.45 am ; T at 805.9 = 894 at 9.00 am
898 9.05 am
894 4.15
905 9.16

6 7 8 9 10 11 12
640/200/1800 894 905 906 904 899 890 870
680/150/1000 891 902 904 902 908 892 872
720/300/1000 927 939 943 944 947 949 940
720/200/1000 922 937 940 940 939 938 925
730/100/1000 912 924 926 927 928 928 918
730/175/1000 912 925 928 929 929 928 918 10.10
730/150/1000 916 929 932 932 933 933 921 10.18
730/150/1000 916 930 933 933 934 934 922 10.35
720/180 917 930 933 934 935 923 10.30
720 LZE 1000 915 928 931 931 931 930 917 16.30

Setting Temp A V P CP = 67%
T 720 730 10.6 145 154 1 373 302 MPa 1.37
C 630 3.5 9 32 4 63 2.57 0.70 W K
B 1000 657 13.4 20.7 277 1.54 154

Spice T = 931 Control SP0 = 657
### To SP(7) = 850

<table>
<thead>
<tr>
<th>Setting Temp</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>660</td>
<td>1089</td>
<td>10.5</td>
<td>23</td>
<td>242</td>
</tr>
<tr>
<td>C</td>
<td>425</td>
<td>918</td>
<td>5.2</td>
<td>27.5</td>
<td>143</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>850</td>
<td>14.2</td>
<td>31.6</td>
<td>449</td>
</tr>
</tbody>
</table>

Spec T = 1458 on SP(7) = 850

---

### To SP(7) = 750

<table>
<thead>
<tr>
<th>Setting Temp</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>690</td>
<td>842</td>
<td>18.7</td>
<td>18</td>
<td>193</td>
</tr>
<tr>
<td>C</td>
<td>225</td>
<td>722</td>
<td>3.6</td>
<td>12.2</td>
<td>44</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>750</td>
<td>13.9</td>
<td>25.2</td>
<td>350</td>
</tr>
</tbody>
</table>

Spec T = 1084 on SP(7) = 750

---

### Now down to SP(7) = 820

<table>
<thead>
<tr>
<th>Setting Temp</th>
<th>A</th>
<th>V</th>
<th>P</th>
<th>OP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>670</td>
<td>1255</td>
<td>12.8</td>
<td>12.8</td>
<td>1297</td>
</tr>
<tr>
<td>C</td>
<td>450</td>
<td>1241</td>
<td>12.6</td>
<td>12.6</td>
<td>1267</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>1232</td>
<td>12.3</td>
<td>12.3</td>
<td>1234</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>1204</td>
<td>12.1</td>
<td>12.1</td>
<td>1219</td>
</tr>
</tbody>
</table>

---
Some load of 1000/1500 pump every few minutes

\[ Q_{in} = 0.92 \]

\[ Q_{out} = 0.92 \]

\[ y = 2 \]

\[ R = 2.01 \]

\[ P_{in} = 1.5 \]

\[ 2 \times 8 = 16 \]

\[ 0.28 = 0.92 \text{ of weather cool} \]
Setting Temp. T A V R P OP = 74.5%
E T 640 948 10.5 14.5 1.86 205
C 350 808 4.4 18.2 4.14 80 685W 0.72W/K
B 1030 820 14.3 28.0 1.96 400

Spec T = 1219 on S1P7 = 820

Pumped to 400 MPa on same settings.
640 | 350 | 1000 | 1184 | 1191 | 1190 | 1185 | 1184 | 1179 | 1156
700 | 350 | 1000 | 1191 | 1201 | 120 | 1199 | 1200 | 120 | 1186

Setting T A V R P OP = 75.5%
T 700(-) 926 11.2 20.7 1.852 232
C 350(+) 790 4.5 18.4 4.09 83 708W 0.76W/K
B 1030 820 14.3 27.5 1.92 343

Spec T = 1206 on S1P7 = 820 at 400 MPa.

George's Visit

Found that the link DS-1 on ASC02/2 (which we had checked was in position earlier) was open-circuit. Replaced — immediately. The AD & LF drives were OK, as originally.

But TC drive still no good — drives full speed. Found there was no return voltage from TC; cable lacks a couple wires connecting to D/E9 input to utility board.

11/4/95
Some load of 1000 kg is pumped every four minutes.
here the accuracy of the presented method by comparing solutions for SIFs with ones obtained elsewhere, either analytically or numerically.

a. Two-Dimensional Problems

In the test problem of two collinear cracks considered previously the errors in SIFs are on the order of 1% when spacings between cracks are on the order of $10^{-1}$ of the crack length. Note that such accuracy is achieved in spite of the fact that the interaction effect raises SIFs at the inner tips by 47%; i.e., it is quite significant. Even at spacings as small as 0.02 of the crack length (SIFs at the inner tips are increased more than by a factor of 2), the accuracy is still satisfactory for many purposes (on the order of 10%).

Similar results hold for a periodic row of collinear cracks (see Kachanov, 1987); the error is 2.9% at the spacings of $10^{-1}$ of the crack length (when SIFs are increased by a factor of 2.2 by interactions) and 13% at the spacings of 0.025 of the crack length (when SIFs are increased by a factor of 4). These examples are not representative, though, since accuracy in the collinear arrangements is unusually good. In other geometries, accuracy is substantially worse; however, it still remains relatively good. It remains within several percent at spacings between cracks several times smaller than the crack lengths. The worst configuration is the one of partially shifted stacked cracks; in this case, the method remains accurate at spacings of about one-third of the crack lengths.

b. Three-Dimensional Problems

In 3-D problems, the accuracy is generally much better than in the similar 2-D ones. Referring to Kachanov and Laures (1989) for a detailed discussion, we review here the basic findings.

Most of the 3-D solutions available in literature are limited to the case when the spacings between cracks are not too small so that the interactions remain relatively weak. Since our method is asymptotically exact in these cases (see discussion below), these problems do not constitute challenging tests. Comparison with the available results for moderate and strong interactions yields the following results.

1. The configuration analyzed (numerically) by Isida et al. (1985) consisted of parallel "offset" stacked cracks of elliptical shape under mode I loading. In those with a circular shape, the smallest spacing between cracks considered was 0.5 of the crack diameter; the ratios $K/I/K_0$ were calculated for the "offsets" of 0 (axisymmetrical configuration), 0.5, and 1.5 of the crack diameter. The calculated ratios $K/I/K_0$ were, as to be approximately from the graphs, 0.66, 0.83, 0.97 and 1.02. They fit coincide, within these digits, with the ones obtained by our method.

2. Uflyand (1967) obtained results for the axisymmetrical configuration parallel stacked cracks under mode I loading, at the spacings between cracks of 0.25, 0.5 and 1.0 of the crack diameter. His results: $K/I/K_0 = 0.7703, 0.8324$ and 0.9191 whereas our results are 0.761, 0.8249 and 0.9176. The disagreement is very small (and may be attributed partly to the procedure of numerical integration used by Uflyand: trapezoidal rule with 10 integration points).

3. Fabrikant (1987a, 1989) considered the problem of very closely spaced, strongly interacting coplanar cracks by reducing it to a new form of integral equation that are nonsingular and can be solved by rapid converging iterations. For two coplanar cracks of equal size, the results converged up to spacings as small as $2.5 \times 10^{-4}$ of the crack diameter (mode I loading) and 0.005 (shear loading). Under mode I loading, the maximal error in SIF along the crack edge (at the point of closest spacing) is only 0.7% and 3.8% at the spacings of 0.05 and $2.5 \times 10^{-4}$ the crack diameter, becoming indistinguishable at the points along the edge that are farther away from the point of the closest spacing. Under mode II loading, the results are similar (see Kachanov and Laures, 1989 for details).

6. Comparison with Polynomial Approximation Techniques

The advantages of the method are that (1) it applies to both 2-D and 3-D configurations with equal ease, being particularly accurate in 3-D, and (2) it is sufficiently simple to allow computer experiments on large arrays of interacting cracks, in both 2-D and 3-D (see Section V and VI).

It is interesting to compare it with the frequently used 2-D technique of polynomial expansions of tractions on cracks and finding the polynomial coefficients from a system of linear algebraic equations. There are two basic versions of the technique of polynomial expansions:

1. Traction on each considered crack are approximated by polynomial
2. When considering tractions on a given crack, polynomial approximation is applied to tractions on the other cracks.
<table>
<thead>
<tr>
<th>Setting</th>
<th>Temp</th>
<th>A</th>
<th>V</th>
<th>R</th>
<th>P</th>
<th>OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>640</td>
<td>9.48</td>
<td>10.5</td>
<td>19.5</td>
<td>18.6</td>
<td>205</td>
</tr>
<tr>
<td>C</td>
<td>350</td>
<td>8.08</td>
<td>4.4</td>
<td>18.2</td>
<td>4.14</td>
<td>83</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>8.20</td>
<td>14.3</td>
<td>28.0</td>
<td>1.96</td>
<td>400</td>
</tr>
</tbody>
</table>

Spec T = 1219, OP = 74.29°

Pumped to 4000 MPa on same settings.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Temp</th>
<th>A</th>
<th>V</th>
<th>R</th>
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<th>OP</th>
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<td>700</td>
<td>9.26</td>
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<td>232</td>
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<tr>
<td>C</td>
<td>350</td>
<td>7.90</td>
<td>4.5</td>
<td>18.4</td>
<td>4.09</td>
<td>83</td>
</tr>
<tr>
<td>B</td>
<td>1000</td>
<td>8.20</td>
<td>14.3</td>
<td>27.5</td>
<td>1.92</td>
<td>393</td>
</tr>
</tbody>
</table>

Spec T = 1201, OP = 820 at 4000 MPa.

11/4/95

George's Visit

Found that the link DS-1 on ASCO 2/2 (which we had checked was in position, either) was open-circuit. Replaced — immediately, the AD 91F drivers were OK, as originally.

But TC drive still no good — drivers fully good. Found there was no return voltage from TC; cable lacks a couple wires connecting to D69 input to utility board.
ADS offsets:

AD  -0.80
IF  -0.22
EF  -13.03

PID for AD IF 50/10/100
Test on Carrara Marble

300 Mpa 850 K 10^-5 strain rate, 40 5%
Use setting 730/100/1000 for furnace, SP(5) = 660 K

Furnace: SP(5) = 670 ; Temp Spec = 852 K
Setting Temp A V R P 0P = 67%
T 730 670 10.7 14.2 152.2
C 100 5.56 ~3 ~0 0.390 0.67 W^-1
B 1000 5.94 13.2 18 238.8

Peak load = 12.3 kN
Tension at 12.5 kN

Finished up driving with PID = 100/10/50; went into oscillation with more than I = 12 in an attempt to get force from 12.4 up to 12.5. Probably best to underdrive a bit & run at 12.4, allowing for this in choosing set point.
The Set-up

After correspondence with Norm, modified cable from distri.

Board to PICS

At Dbend: red to 3, black to 4
changed shield to 8
PICS end: black to 3, red to 4, link 9 & 5
changed shield to 8.

Now works but changed R4 on DB from 1k - 15k.
Now Catto Cbl on PICS is 650.

At any low speed, it oscillates, so took out the larger
 capacitor (for link 1:365) - didn't work.
Put in smaller capacitor (100pF), hard wired to
trans is freed.
Now runs nicely.

George has also increased the values for P, I & D -
effective on all channels & got to be determined
(about 4x).
Ductile Creep Run

$\phi = 1.00$  $l = 20.25$  Bobbin Gap as received, room dry.
T/C pos. at bench ~ 10.2.

Set pressure 400 MPa 890 K in 35.2 (htc)

Put SP = 1040 K 4a for a start, to go to spec T = 1370
$9$ settings 65/500/1000 go to SP at 3.15 pm

Had to go to T/C control & monitor on 5. PID = 40/100/25

Did deform run to ~ 3.1%, ~ 9.2 kN.

Pressure ~ 380 MPa, not holding well.
Crimp run in stress mode at 115-145 MPa $\sigma = 0.3$

Ended run 3 pushed off.
LCC now 0.24 kN.

Specimen that assembly had a jacket puncture at bottom end of specimen - broken bend piece was off.

Also interin pin, button, was not connected.
TP 01/12 = $36.4$
Furnace PID = 40/100/25

Need chart reader to switch channels after changes.

* TG only -600 +600

Current stress on AD5 screen in stress mode?

* Spike of 1 in Temp still

Problems of extension TP

With IF = -0.5 set contact force -1 & head speed -5

Force builds up in extension & does not stabilize at -1.

Went to -8 before I stopped it

TSR stage on quenching with IC still showing

During extension, MAC running screen says displacement type: COMP
Carrara Extension Run

Pressed to 85 Mpa.
Put furnace on t=660; spec temp came to 846 K.
Changed to t=663

<table>
<thead>
<tr>
<th>Setting</th>
<th>Temp</th>
<th>A</th>
<th>V</th>
<th>R</th>
<th>P</th>
<th>OP</th>
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<tr>
<td>T</td>
<td>730</td>
<td>663</td>
<td>10.8</td>
<td>14.4</td>
<td>133</td>
<td>156</td>
</tr>
<tr>
<td>L</td>
<td>100</td>
<td>542</td>
<td>2</td>
<td>~2</td>
<td>(1)</td>
<td>2</td>
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<tr>
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<td>1000</td>
<td>581</td>
<td>13.4</td>
<td>17.2</td>
<td>1.28</td>
<td>230</td>
</tr>
</tbody>
</table>

TP in comp: 36.5
Eat: 344.4

In TP screen, 62c in IF made at 350/20/100.
still OK at 300/10/100
OK at 300/10/100

Running on 1st kg in:
- 400/7/400
- 400/8/200
- 400/7/200

Ramped down OK. Not yet into 62c in AAD = 2 mm overcut
stopped on P & started again. Ramped up in cat.
OK.

Had to stop 62c during unloading, at lower load.

Another run, somewhat higher stress. 350/7/200
There are occasional upward steps in stress
which do not seem to respond systematically to PID tuning
They may be due to variations in friction on piston.

Third run started at -55 KN, ramped to -14.0
PID still 350/10/7/200
Zero drift of -0.3
<table>
<thead>
<tr>
<th>Load (lbs)</th>
<th>Bottom</th>
<th>Top</th>
<th>Haard</th>
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<tr>
<td>20</td>
<td>583.97</td>
<td>779.88</td>
<td>195.91</td>
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<tr>
<td>1000</td>
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<td>780.44</td>
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<td>586.57</td>
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<tr>
<td>8000</td>
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<td>781.88</td>
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<tr>
<td>9000</td>
<td>589.49</td>
<td>784.88</td>
<td>192.39</td>
</tr>
<tr>
<td>10000</td>
<td>590.07</td>
<td>782.04</td>
<td>191.97</td>
</tr>
</tbody>
</table>

On way down, approached from below at each
PID:

The square waveform of 5 Hz.
For load/strain, use dummy specimen, apply small pre-tension.
For positioning, dummy spec. not required.
Act amplitude low enough to remain in elastic range of spec. y with 50 g/cm.

P: Square wave to have v. steep rise & fall with some overshoot. If rounded, increase P.
   If large overshoot or ringing at top, decrease P.

D: Used to minimize transient overshoot on loading. Set for small overshoot without
   rounding corners of square wave. Setting too high can incur system noise level.

I: Compensate for any steady-state error between command & feedback. If
   too high, get low freq. oscillation. Below this, value not critical.
   Typical 1 pa sec.
Originally, PICS on limit of MAC said not there. 
Found limit was CRL — reset.
PICS now OK — says on no limits to back question. 
DMAC still says PICS not there.

2. When try to run PCSBoot, new members do not get through — still communication problem.

3. Actuator oscillating on previous AD PID’s. 
Power amplif looks OK, no 5 jumper in place.

AD behavior was OK up to time of oil spill, when the CP control was used. After this, a problem. 
Tried other power amplifiers — the same.
<table>
<thead>
<tr>
<th></th>
<th>1.00000000000000000000e+0</th>
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<tr>
<td>2</td>
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</tr>
<tr>
<td>10</td>
<td>1.00000000000000000000e+1</td>
</tr>
</tbody>
</table>
Possible action:
1. Write to George
2. Repeat furnace calibrations & check bleed; try 500 MPA
3. Do LLC calib; sort out ELC
4. Check pre pressure connections
a. Two Coplanar Cracks of Equal Radius a Under Tensile Remote Loading

Here, the distance between the crack centers $2b \gg a$. Taking the far-field asymptotics of the $\sigma_{zz}$-component of the standard mode I field and simply adding it to the $\sigma^c$-induced traction, one obtains

$$K_1 = K_1^0[1 + (a/b)^3/12\pi]$$

(3.30)

The second term in the brackets is the first-order correction for crack interaction. This result recovers the one obtained by much lengthier means by Collins (1962).

b. Two Coplanar Cracks of Different Radii, $a_1$ and $a_2$, Tensile Loading

Here, the distance between crack centers $2b \gg a_1, a_2$. Following the same steps, i.e., evaluating the asymptotic far field generated by crack 1(2) at the center of crack 2(1), one obtains

$$K_1^{(1)} = K_1^{10}[1 + (a_2/b)^3/12\pi], \quad K_1^{(2)} = K_1^{10}[1 + (a_1/b)^3/12\pi]$$

(3.31)

c. Two Stacked Cracks of Equal Radius a, Tensile Loading

Here, the distance between crack centers $2b \gg a$. The asymptotic expression for the stress $\sigma_{zz}$ generated by a crack loaded by a uniform pressure $p$ at the far away point $b$ above its center is $\sigma_{zz} = -p(2/3\pi)(b/a)$ so that

$$K_1 = K_1^0[1 - (2/3\pi)(a/b)^3]$$

(3.32)

where the minus sign indicates that the effect of interaction is shielding.

d. Two Stacked Cracks of Different Radii under Mode I Loading, Tensile Loading

Here, the distance between crack centers $2b \gg a_1, a_2$

$$K_1^{(1)} = K_1^{10}[1 - (2/3\pi)(a_2/b)^3], \quad K_1^{(2)} = K_1^{10}[1 - (2/3\pi)(a_1/b)^3]$$

(3.33)

c. Infinite Stack of Cracks of Equal Radius a, Tensile Loading

Here, the distance between crack centers $2b \gg a$:

$$K_1 = K_1^0[1 - (2/3\pi)(a/b)^3] \left[ 1 + \frac{1}{2} \left( \frac{1}{4} \right)^3 + \ldots \right]$$

$$K_1 = K_1^0[1 - (2/3\pi)(a/b)^3]$$

(3.34)

where $\zeta(3) = 1.202$ is the zeta-function of argument 3. Some of these results recover solutions obtained earlier in the literature by much lengthier means.

IV. Various Effects Produced by Crack Interactions

Using the method of analysis outlined in Section III, we discuss various effects produced by interactions of cracks. In this section, we focus our attention on SIFs (effective elastic properties are discussed in Section VI). Solutions of various interaction problems were obtained by the method described in Section III.

A. Stress Shielding and Stress Amplification. Two- and Three-Dimensional Interactions

Crack interactions may produce either stress amplification (increase of SIFs) or stress shielding (decrease of SIFs), depending on the geometry of the configuration and, for the same geometry, on the mode of loading. Here, we examine these effects by analyzing several representative geometries.

1. 2-D Geometries

a. Mode I Loading

Collinear configurations are characterized by the amplifying effect of interactions (although the amplifying effect is the strongest when the symmetry is slightly “disturbed,” see the discussion in Section C). This is
where \( \sigma^e_\nu, \sigma^e_\tau \) are the “standard” stress fields discussed in Section II (field generated by the jth crack loaded by uniform tractions, normal and shear of unit intensity) and I is a 2-D unit tensor.

The problem is thus reduced to finding the average tractions \( \langle t^i \rangle \) on cracks. They are found by averaging (3.9) along the ith crack line:

\[
\langle p^i \rangle = p^{(0)} + \sum_{j \neq i} \{ \Lambda^e_{\nu} \langle p^j \rangle + \Lambda^e_{\tau} \langle \tau^j \rangle \}
\]

\[
\langle \tau^i \rangle = \tau^{(0)} + \sum_{j \neq i} \{ \Lambda^e_{\nu} \langle p^j \rangle + \Lambda^e_{\tau} \langle \tau^j \rangle \}
\]

(3.10)

where the transmission \( \Lambda \)-factors characterize attenuation of the average normal and shear tractions in transmission of stresses from one crack onto the other crack sites; for example, \( \Lambda^e_{\nu} \) is the average shear traction induced at the site of crack 1 in a continuous material by the normal uniform unit load on crack 3. Note that, generally, \( \Lambda^e \neq \Lambda^i \) (for example, the impact of a small crack on a larger one is smaller than vice versa).

Equations (3.10) constitute a system of \( 2N \) linear algebraic equations for the average tractions. They can be written in a compact vectorial form:

\[
(2\delta_{ii}I - \Lambda^d) \langle t^i \rangle = \tau^{(0)}
\]

(3.11)

where summation over all crack numbers \( i = 1, 2, \ldots, N \) is assumed. Tensorial element \( \Lambda^d \) represents the average traction vector generated along the kth crack line by the ith crack loaded by a uniform traction of arbitrary direction and unit intensity (Fig. 11); i.e., it transforms the vector of average traction on the “source” crack into the average traction vector on the “recipient” crack line. Diagonal element \( \Lambda_{ii}^d \) (characterizing “interaction of a crack with itself”) is defined as a unit tensor I (consistently with the fact that tractions induced by the ith crack on lines close to \( l^i \) are close to the ones applied on the crack).

The righthand part of (3.11) represents the remote loading conditions. The lefthand part characterizes the intrinsic geometry of the crack array, which is
TSCR Hysterisis got reset to 12.5% at some point (9-4-95)

Downstream poe pressure gauge limit seemed to kick P0
AD the flag on screen.

TSCR frozen on quitting IHC program — came back spontaneously
— or is this an illusion?
1. Balance bridge at B, using AC meter or oscilloscope

2. Set front panel offset pot to 500

3. Adjust offset pot on distribution board to give zero meter reading

4. Adjust zero offset in PICS to also give zero PICS reading if necessary

5. Front of box:

   TP  O
   TP grid  O
   20  O
   50  O

   DB 9

   to

   [Diagram of electronic circuit with labels and connections, including buffer amplifier, oscilloscope/demodulator, and distribution board connections to AIC and PICS, with notes on inside housing and specific adjustments.