



NuMI Repairs for Hot Components

(1 sievert = 100 rem)

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 September 9, 2006
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 Page 1

Problem	On Contact	Repair	Method
Target internal water leak		Removed target upstream window to drain water	Long handled tool through work-cell door
Target drive jammed	55 r/hr	Diagnosis in place via camera, then swap target carriers	All remote operations via camera or behind shielding
Resin beads stuck in Horn 1 water header		Blow and vacuum beads out of header with air	Work at top of module in place, behind shielding
Horn 1 water leak at spray line ceramic	75 r/hr	Swap out section with compression fittings	Temporary shielding slot in front of work-cell
Horn 2 ground fault		Put new foot on horn 2	Hands-on through work-cell door
Horn 2 air leak at suction line ceramic	7 r/hr	Cut out old suction line, installed new line with compression fittings	Temporary shielding slot in front of work-cell

from early design review

NuMI Target Hall Radioactive Component Handling Considerations

NBI2006
September 9, 2006
MI Repairs for Hot Components
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Page 2

NuMI Target Hall Utilizes Three Basic Beamline Elements

- Horn Protection Baffle & Target Assembly
- Magnetic Focusing Horn 1
- Magnetic Focusing Horn 2

Basic Operational Criteria

- Protection baffle/target assembly and horn 1 require motion capability in beamline chase
- Shielding design should allow the position of horn 2 to be changed along the beamline to accommodate a LE, ME, and HE beamline configuration
- Low energy target design criteria is 10^7 pulse, 1 year lifetime
- Focusing horn 1 design criteria is 10^7 Pulse, 1 year lifetime

We anticipate changing failed horns and targets during the experiment

from early design review

NuMI Target Hall Radioactive Component Handling Considerations

NBI2006
September 9, 2006
NuMI Repairs for Hot Components
Jim Hylan / FNAL
Page 3

Additional Design Specifications

- Positioning mechanism (i.e. module) should be reusable
- Main consideration is component change-out capability
- Secondary consideration is for very limited repair capability (e.g., repairable water leak on a component with relatively low residual activation level)
- Require a spent component storage area



All NuMI target hall beam components and innermost shield layers are installed / removed remotely with crane and cameras

NBI2006
September 9, 2006
NuMI Repairs for Hot Components
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Page 4



Crane includes remote hook rotation.



Steel shielding block being moved.



Water line connections made up from behind shielding

NBI2006
September 9, 2006
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Page 5

Inner water tube
outer tube to turn swage lock nut
at other end of tube

shielding stepped to reduce
direct line-of-sight cracks





NuMI work cell for radio-activated components

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Page 6



Shown during test-assembly
above ground

Lead-glass windows (not
shown)

Remote controlled door

Remotely installable
top shielding



Remote 5-axis lift table *puts components on bottom of alignment modules in work cell*

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September 9, 2006
NuMI Repairs for Hot Components
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Page 7



NuMI target+baffle on lift table



Target on module, ready to crane into beam



Target Alignment Survey

NBI2006
September 9, 2006
NuMI Repairs for Hot Components
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Page 8

Survey of target tip
relative to target
tooling balls

After mount of
target carrier to module

Done through holes
in work-cell
lead-glass windows





Work cell

Target module, initial installation in beam-line

Old target removal on remote lifting fixture





But did some repairs basically by hand

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September 9, 2006
NuMI Repairs for Hot Components
Jim Hylan / FNAL
Page 10



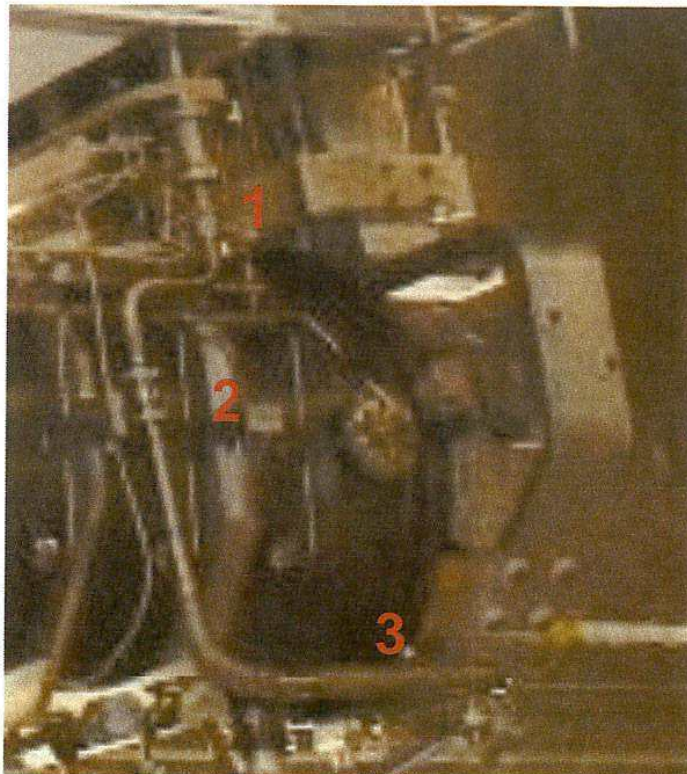
Repaired
water line
on Horn 2



Horn 2 ceramic replacement was challenging because repair required cutting steel pipe

NBI2006
September 9, 2006
NuMI Repairs for Hot Components
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Page 11

30 – 50 R/hr (0.3 - 0.5 Sv/hr) in chase around horn before horn removal



All Doserates in R/hr

After horn removal	O.C.	1 foot	~ 18"
1	8	4.5	3
2	7	4	3
3	5	3	2.5

Allowable ~ 1 minute per person at arms length

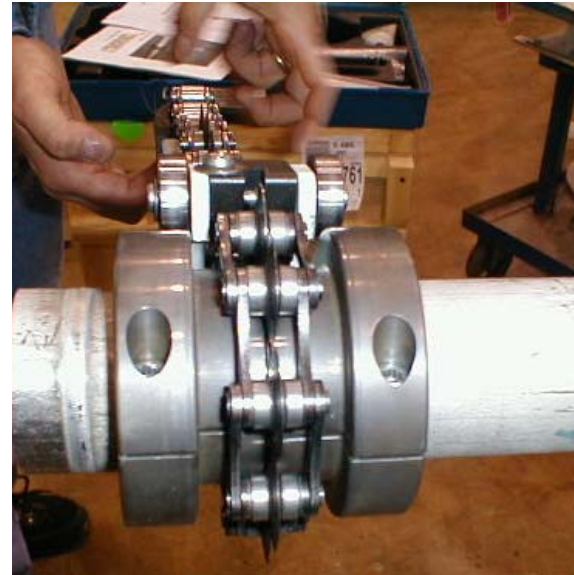


Some pictures from practice – also tried variety of techniques that were not used

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September 9, 2006
NuMI Repairs for Hot Components
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Page 12



Set up temporary shielding
with slot



Cut 2”
steel pipe

No chips

Note alignment
jig



Hydraulic Swaging of compression fitting



Horn 2 suction line ceramic replacement

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September 9, 2006
NuMI Repairs for Hot Components
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Page 13

The ALARA plan estimated about 277 mrem to the repair crew including 25% for contingencies. (~ 1 mrem/second)

The job was done with a total dose of 244 mrem (2.4 mSv)

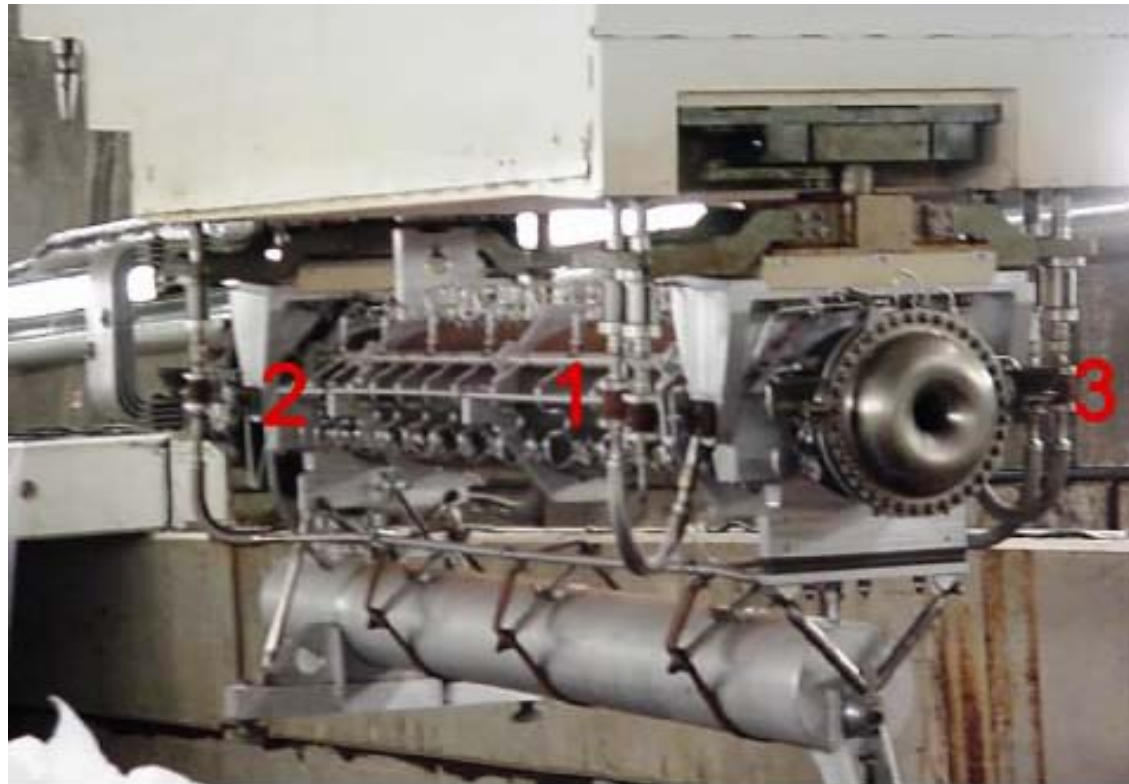
The careful planning, prototyping, fabrication of special tools, and practice paid off.



Horn 1 ceramic replacement was not as complicated, but rates were much higher

75 r/hr (0.75 Sv/hr) on contact
35 r/hr (0.53 Sv/hr) at 1 foot

NBI2006
September 9, 2006
NuMI Repairs for Hot Components
Jim Hylan / FNAL
Page 14



Point	Doserate @ 1 foot (mr/hour)	Doserate On Contact (mr/hour)
1	35000	75000
2	40000	75000
3	35000	80000

This was 10x as much as we had for the Horn 2 repair !

Repair person would get weekly dose limit in a few seconds



Shielding for job

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September 9, 2006
NuMI Repairs for Hot Components
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Page 15



Built an extension
of the work-cell
with window
for work

(Horn is in
work-cell,
behind the door)





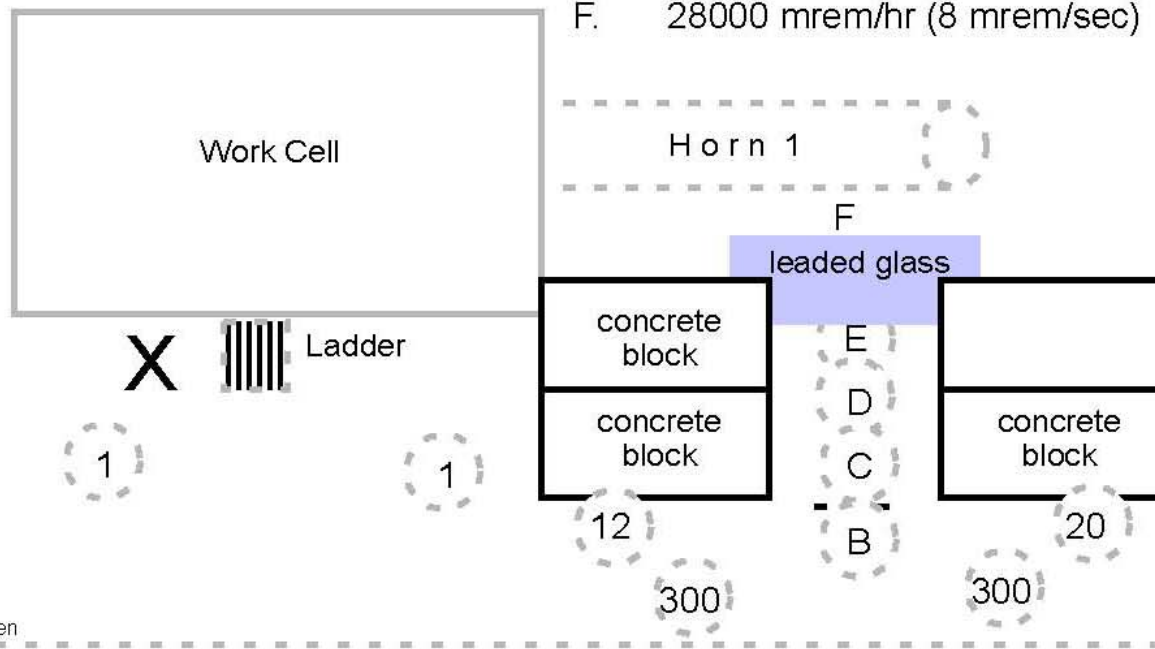
Shielding cut dose for most steps by a factor of three or more



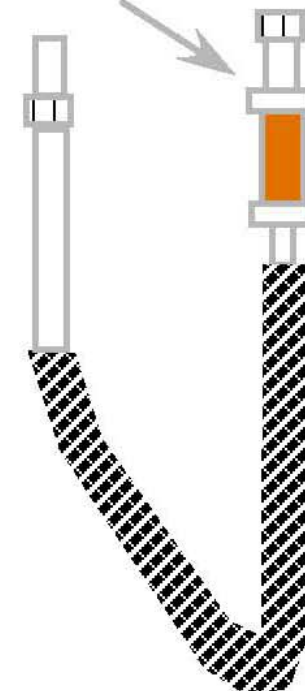
DATE: 8/22/06	TIME: 0900	PURPOSE: Survey for ceramic repair	RWP # N/A
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NuMI Horn 1 Ceramic Repair August 2006 Map 2

- B. 2000 mrem/hr (0.6 mrem/sec)
- C. 3000 mrem/hr (0.8 mrem/sec)
- D. 3000 mrem/hr (0.8 mrem/sec)
- E. 7500 mrem/hr (2 mrem/sec)
- F. 28000 mrem/hr (8 mrem/sec)



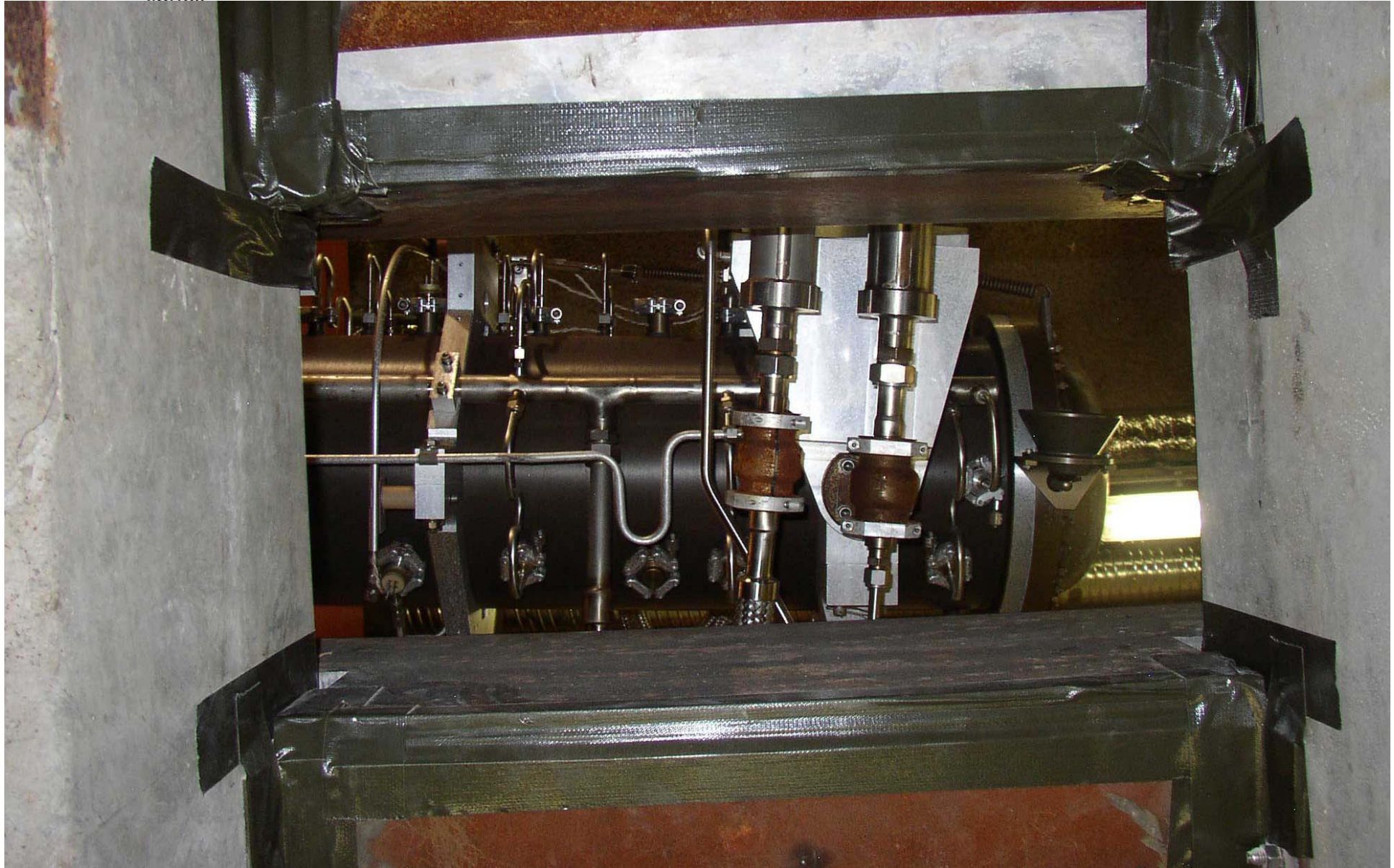
55,000 mrem/hr
 (15 mrem/sec) on contact





View of horn 1 through shielding slot

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September 9, 2006
NuMI Repairs for Hot Components
Jim Hylan / FNAL
Page 17

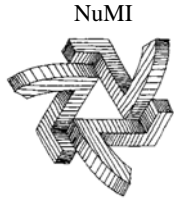




Some specially constructed tools for Horn 1 ceramic line repair

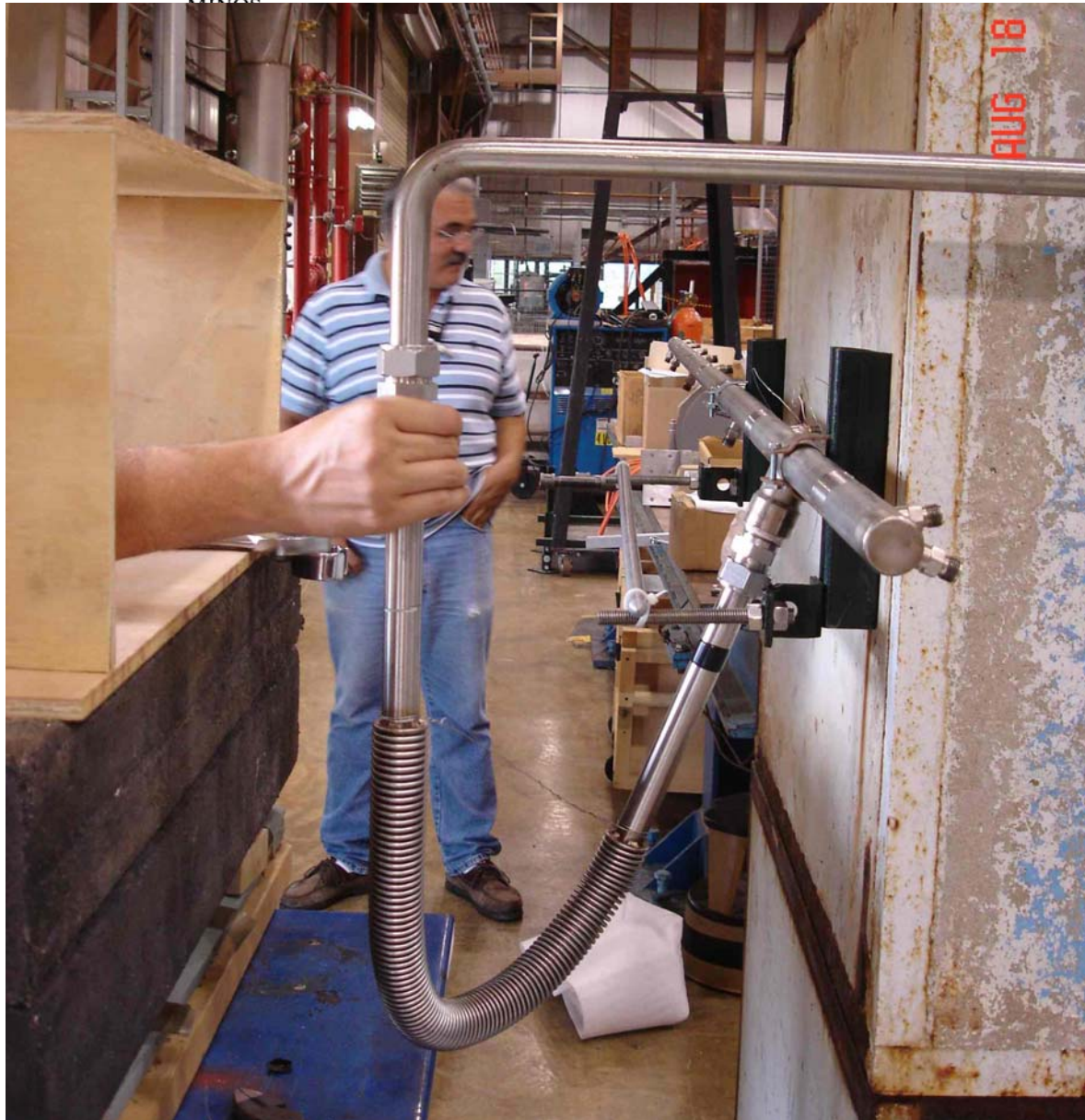
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Page 18





Mock-up and practice

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Page 19



Plan, time, and practice,
practice, practice repair

Needed to undo two
Swagelok fittings,
remove old section,
insert new section,
and tighten two fittings.

Time est: 2 min. of
actual work in slot

Dose for this "2 min." job
was 371 mr, (3.7 mSv)
divided over ~10 people.

The rest of job is in much
lower radiation field,
but dose can be non-negligible
due to time involved.