OAK RIDGE National Laboratory

POWGEN T0 Baseplate Upgrade
A Lesson In Configuration Management

David C. Anderson — Instrument Engineering Group Leader

George Rennich — Instrument Engineer

Jerry Stockton — Neutron Choppers Team Lead

Bill McHargue — Instrument Engineer, Choppers

September 19, 2018

DENIM VII 2018

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

POWGEN History

- POWGEN was one of the initial set of instruments included as part of the SNS project, and was completed in 2008.
- The POWGEN project began at Argonne National Laboratory, and development moved to SNS in 2005 when Instrument Systems moved from ANL to ORNL

These photos were taken by the original installation team in 2007

POWGEN T0 Vibration History

- In July 2014, the Neutron Chopper Team was attempting to install the POWGEN T0 Chopper after Bearing Maintenance
- During testing on the beamline, the chopper's vibration levels (**10 mm/s**) were high enough to trip the set points, and was unable to run at full speed
- The team had previously noticed that the mounting bolts were loose when removing the chopper for maintenance
- Initial investigation into the problem revealed unexpected and strange results – vibration levels increased when the bolts were properly torqued, and were at their lowest level at 5 ft-lbs (7 Nm) of bolt torque
- A vibration expert (Blake Van Hoy) was consulted to analyze the problem

POWGEN T0 Vibration History

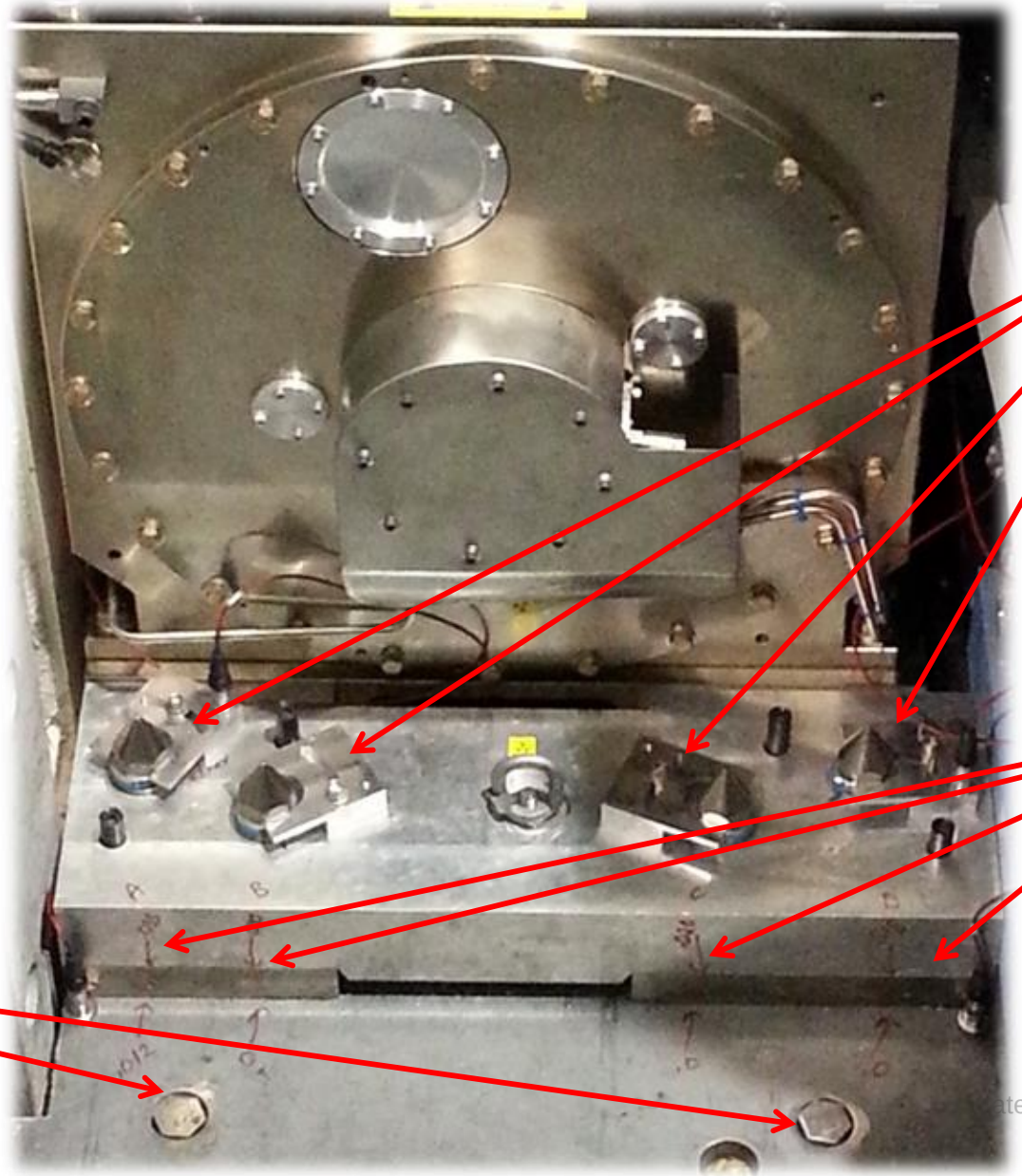
- Conclusion
  - Looseness from some cause has the base acting like a soft foot when coupled hard to the concrete slab that exhibits unequal stiffness across the base
  - When decoupled from the slab the unit runs smoother, however the high frequencies are worse because the unit has enough force to move within the looseness allowed. These high frequencies do not add much to the overall energy but will eventually start to affect the roller elements in the bearings
  - Per ISO 10816-3 velocity levels for severity , where blue is new, green is normal operation , yellow is marginal, and red is you need to do something, this chopper is vacillating between yellow and the lower part of the red zone.
  - This is not an ideal solution but is acceptable in the short term until there is time to investigate and determine the root cause and make the appropriate engineering changes.

-Blake Van Hoy, POWGEN T 0 Chopper Vibration Data Analysis, January 2015

POWGEN T0 Chopper Vibration History

- George Rennich, an ORNL Instrument Engineer, and Bill Turner, ORNL Instrument Designer, developed a preliminary engineering concept for replacing the mounting system with a new one
- Because of the complexity of the replacement, and the expected radiation activation levels, the installation was planned to occur during the long Inner Reflector Plug (IRP) changeout
- A set of "keepers", preventing the bolts from backing out, were designed by Bill and George, and installed on the chopper mounting bolts as a temporary repair
- This repair was good enough for chopper to run with **5 mm/s** vibration
- IRP manufacturing problems delayed the IRP changeout until the Winter and Spring of 2018

Chopper, as repaired, 2015



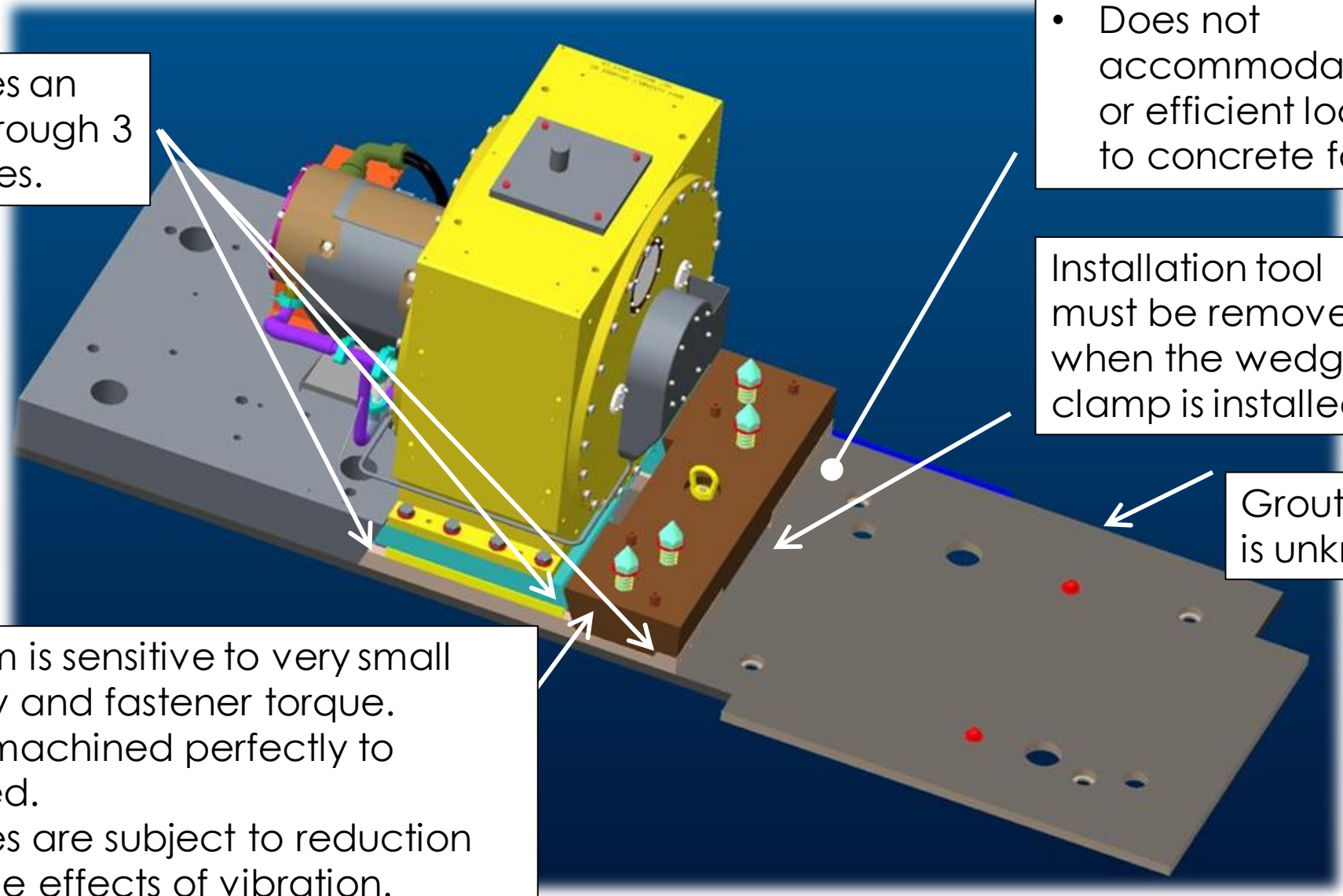
Keepers (to prevent captured bolts from backing out)

These markings show measurement locations – problem investigation included measuring these gaps

These nuts, which attach the baseplate to anchor studs, where ground away during 2007 installation

POWGEN T0 Chopper, original design

Clamp system applies an indirect load path through 3 rigid surface interfaces.



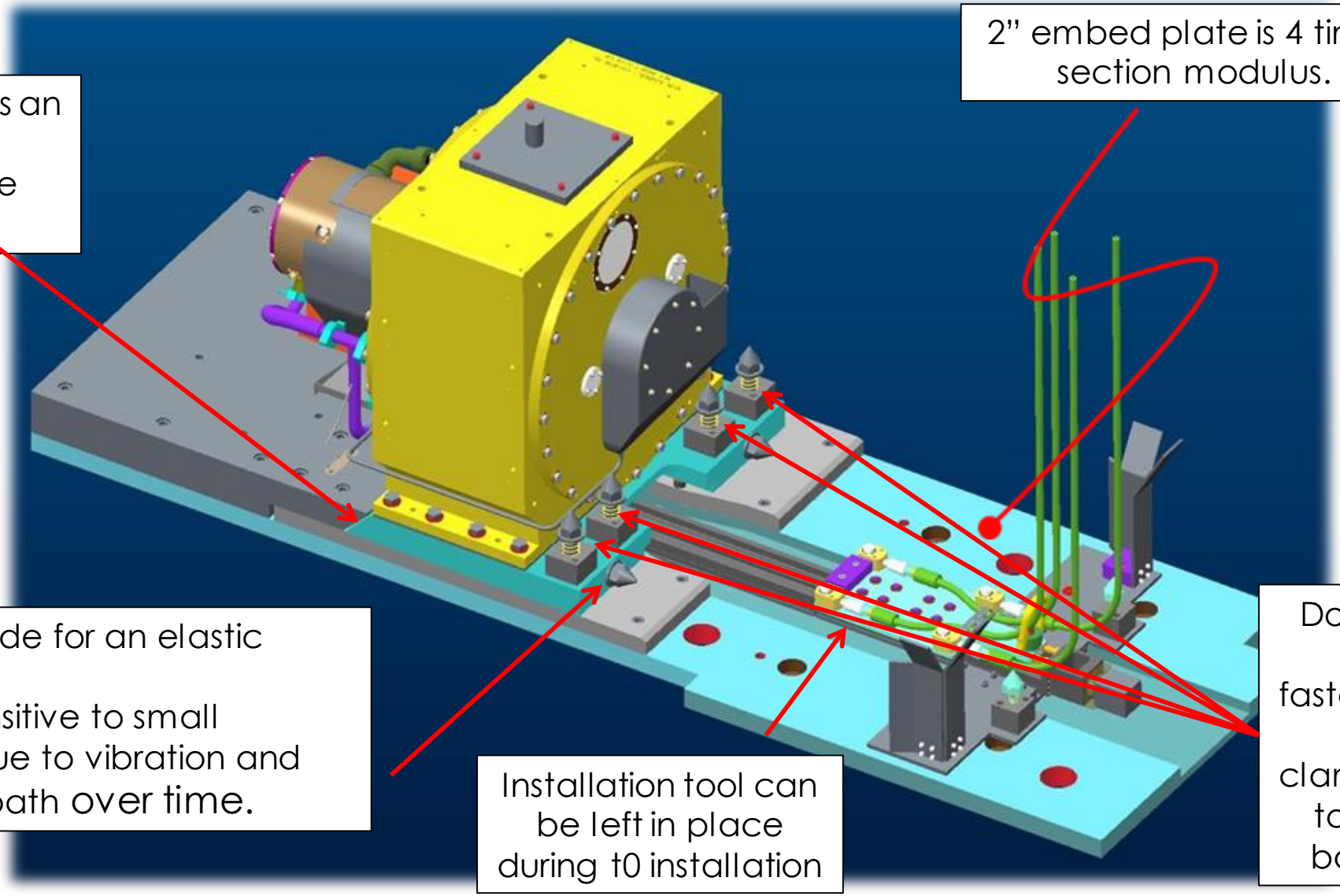
Embed plate is thin.
- Does not accommodate anchors or efficient load transfer to concrete foundation.

Installation tool must be removed when the wedge clamp is installed.

Grout condition is unknown.

The rigid clamp system is sensitive to very small variations in geometry and fastener torque.
- The parts must be machined perfectly to perform as designed.
- The fastener torques are subject to reduction over time due to the effects of vibration.

POWGEN T0 Mounting Redesign



Clamp system applies an indirect load path through 1 rigid surface interface.

2" embed plate is 4 times section modulus.

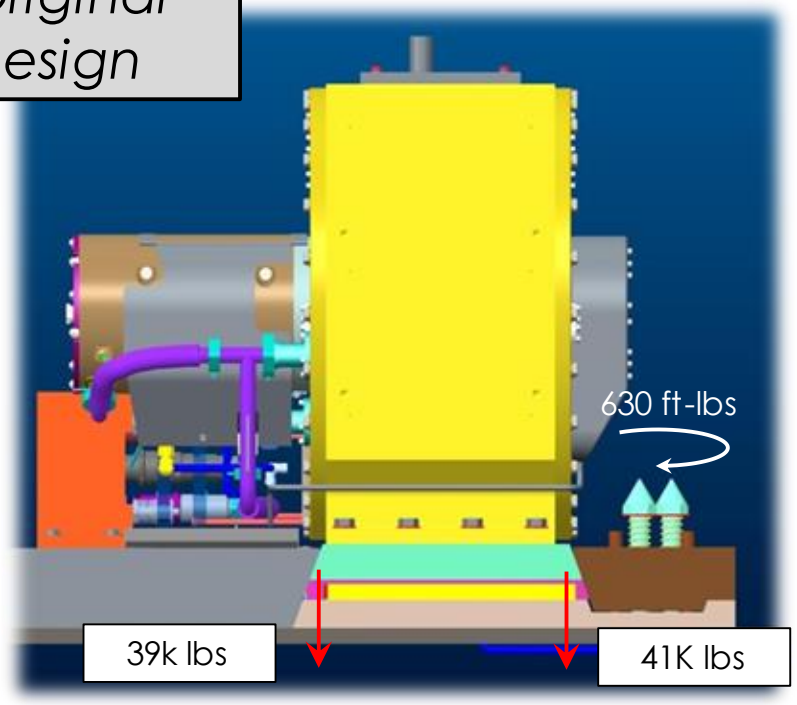
26" clamp screws provide for an elastic clamping system.
The torques are not sensitive to small geometric variations due to vibration and deflection in the load path over time.

Installation tool can be left in place during t0 installation

Downstream remote fasteners apply direct clamping force to chopper base plate.

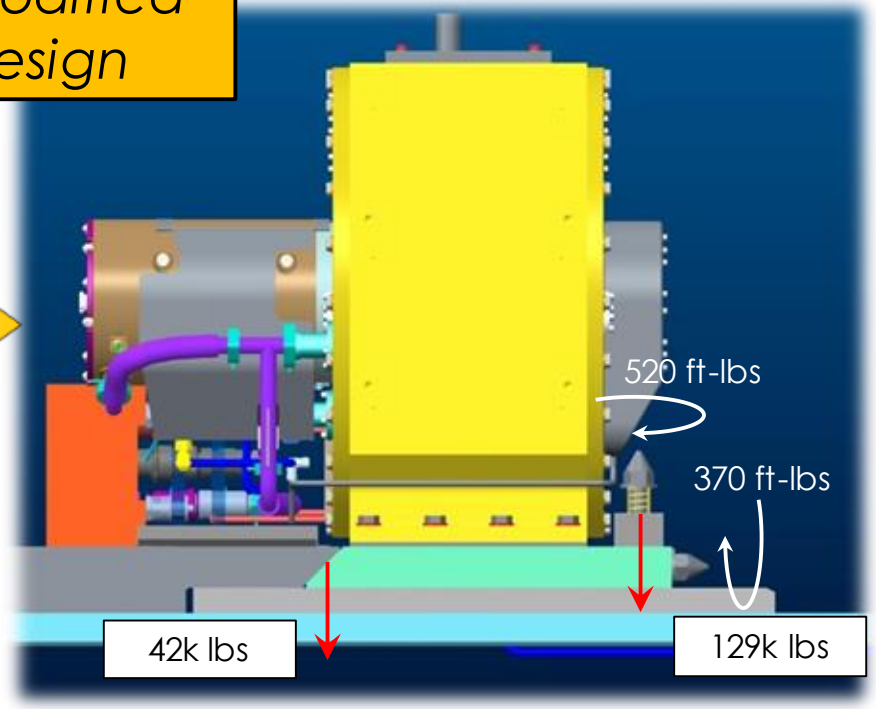
POWGEN T0 Mounting Clamping Force Comparison

Original Design



Maximum torque wedge clamp screws
~630 ft-lbs

Modified Design



Maximum torque upstream clamp screws
~370 ft-lbs

Maximum torque downstream clamp screws
~520 ft-lbs

POWGEN T0 Mounting Redesign

Following delivery, the new mounting system was assembled off-line for pre-installation testing.

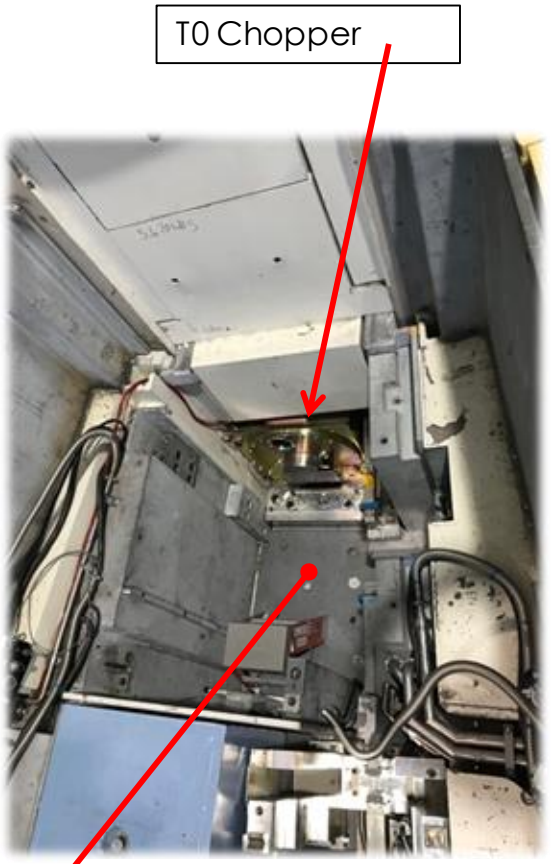
Chopper positional repeatability and installation methodologies were established.

Torques applied to the upstream and downstream clamp screws were checked.

Operation of the electro-hydraulic installation tool was checked.

POWGEN T0 Mounting Upgrade Begins

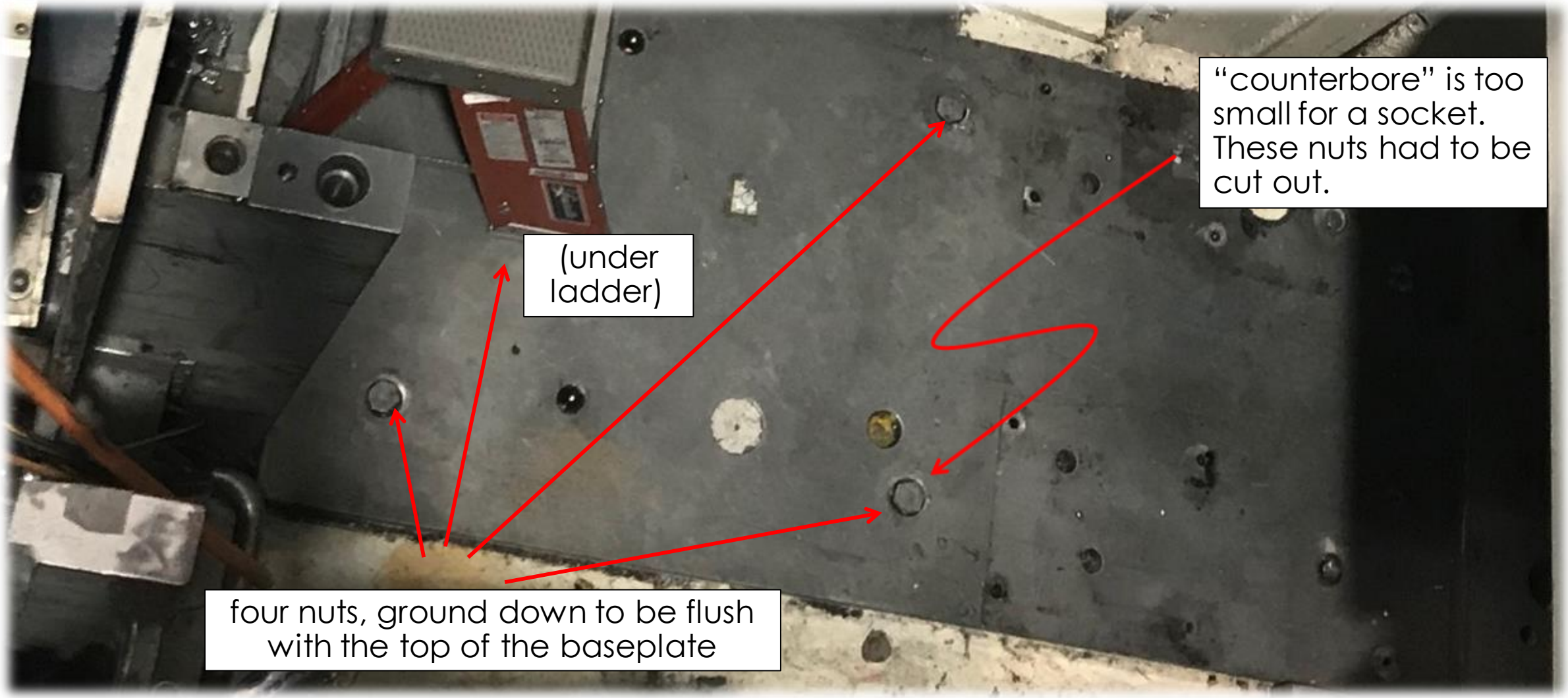
- In December 2017, the long Inner Reflector Plug (IRP) replacement outage begins
- In January 2018, the POWGEN T0 Mounting Upgrade begins with the removal of shielding
- On January 30th, shielding is removed all of the way to the baseplate



POWGEN Shielding Removed to expose T0 Chopper

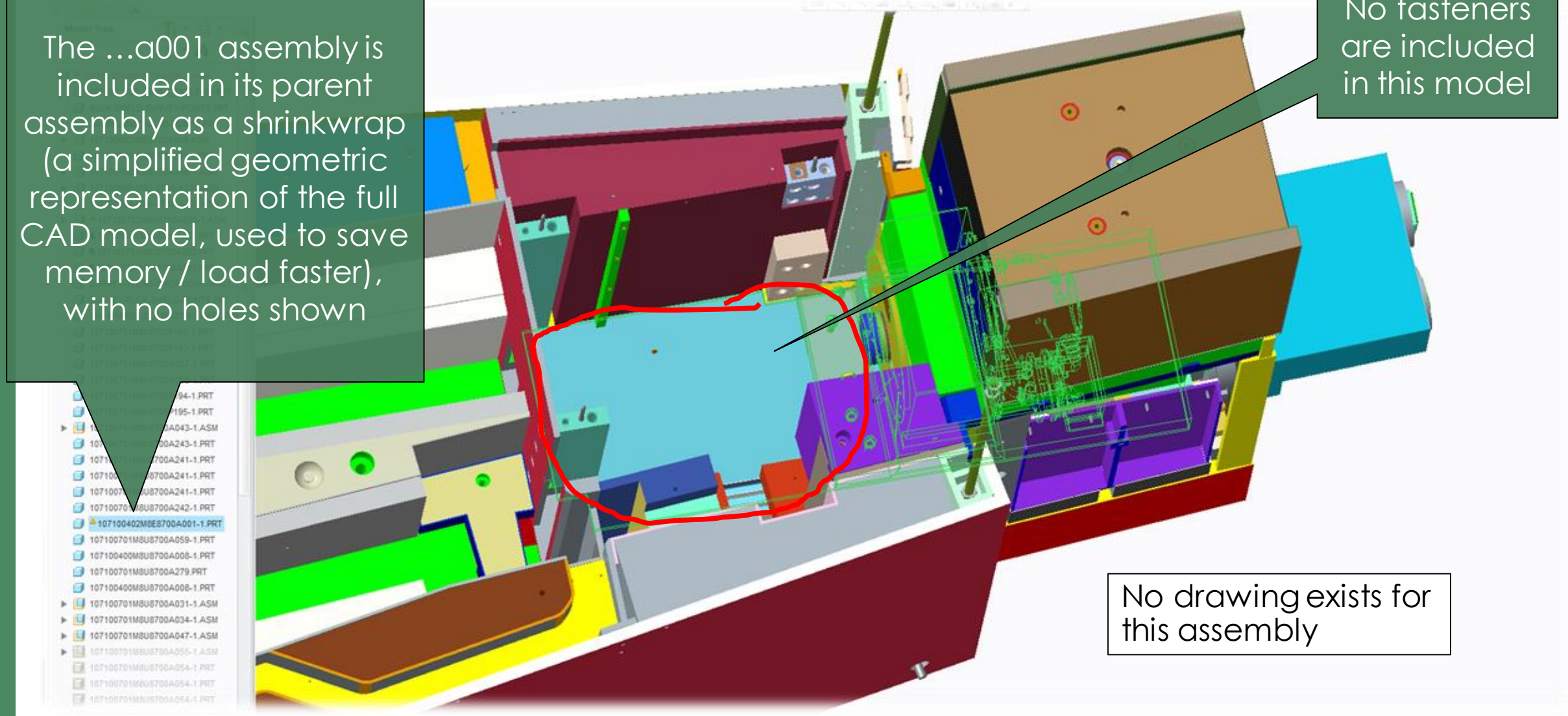
SNS IRP-02 installation

Surprise Number 1 – Holes Not Large Enough For Nuts

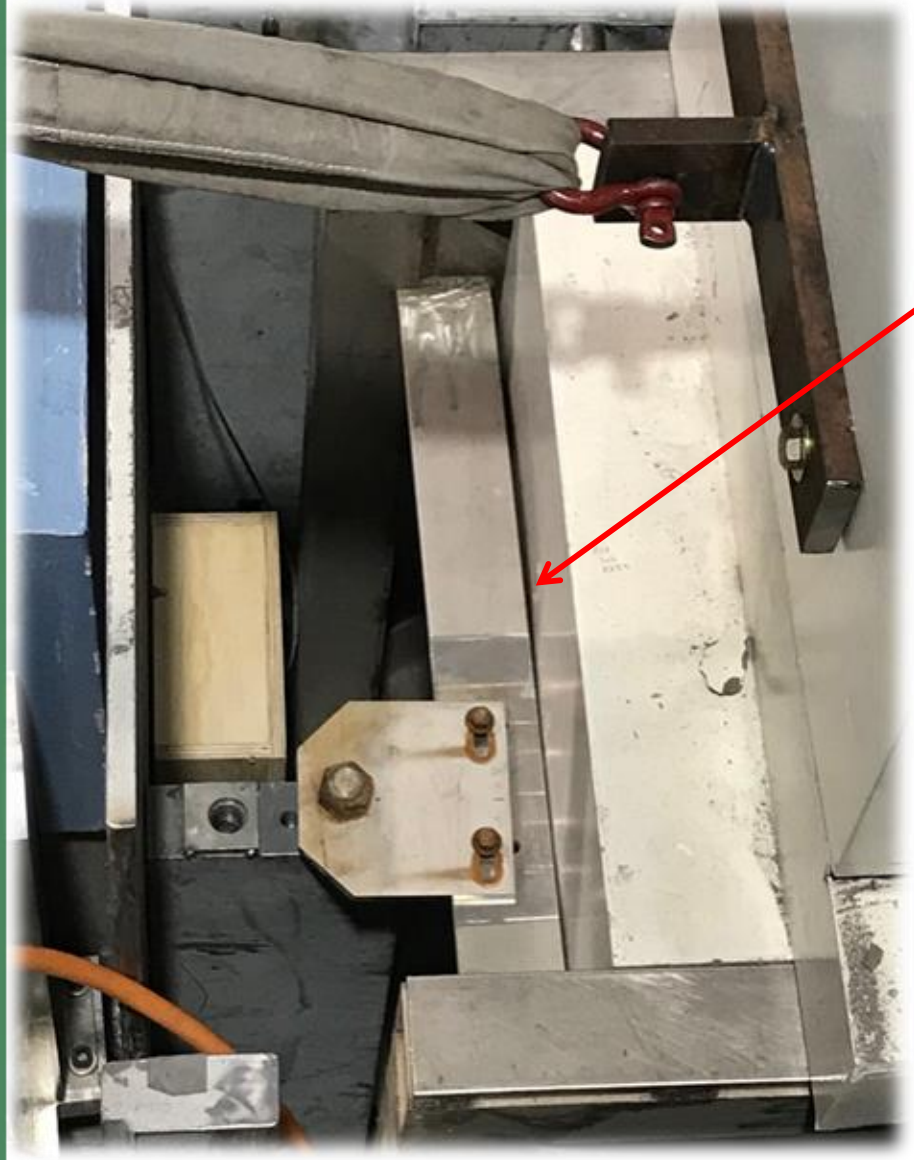


Surprise Number 1 – Holes Not Large Enough For Nuts

The …a001 assembly is included in its parent assembly as a shrinkwrap (a simplified geometric representation of the full CAD model, used to save memory / load faster), with no holes shown



Surprise Number 2 – Shield Blocks Won't Come Out



When the downstream ends of the three stacked blocks are pulled all of the way against the installation fixture …

the upstream end is still under the lintel…

there is no way to get them out!

Surprise Number 3 – Lifting Features? What Lifting Features?

…so, the riggers wedge up the downstream end of the top block …

and put a strap under it

How To Lift A Block That Cannot Be Lifted

Shackles and rigging

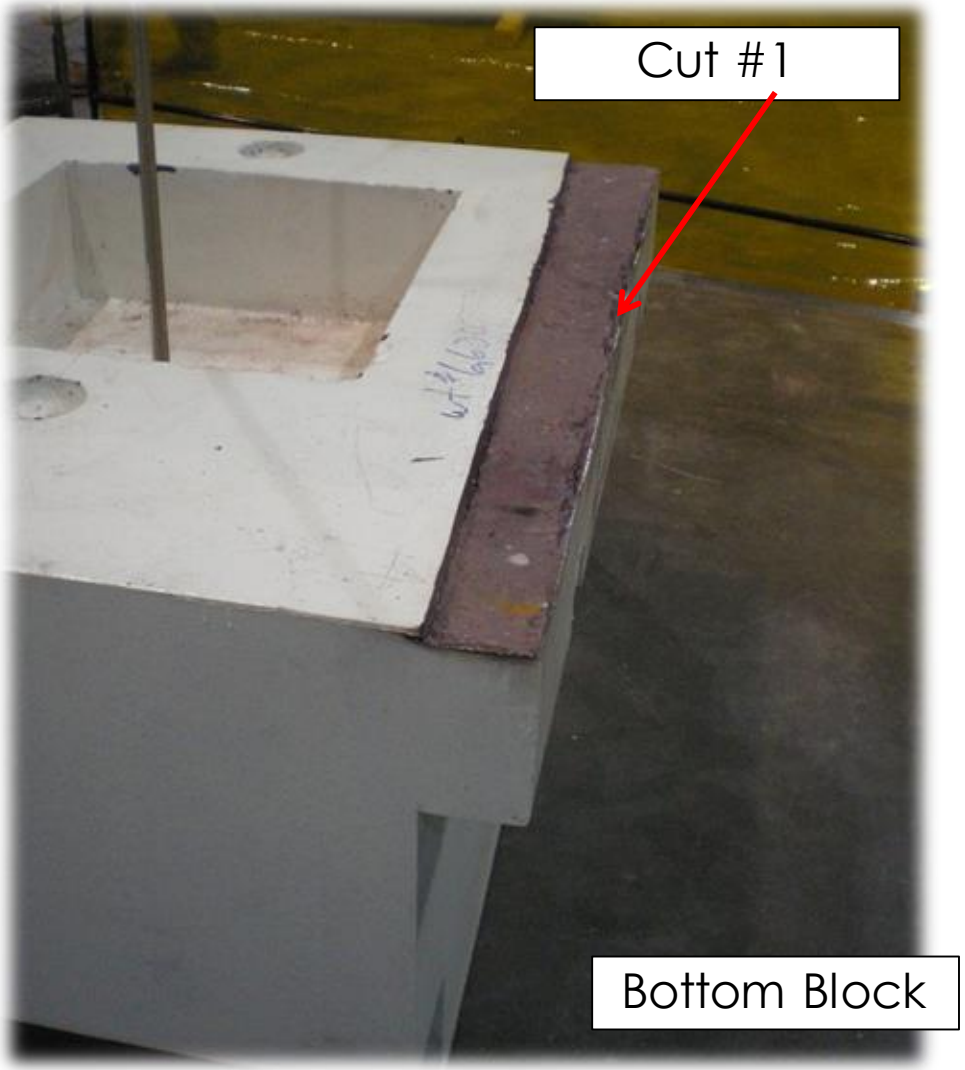
Block is removed

So… How Did The Block Get In?

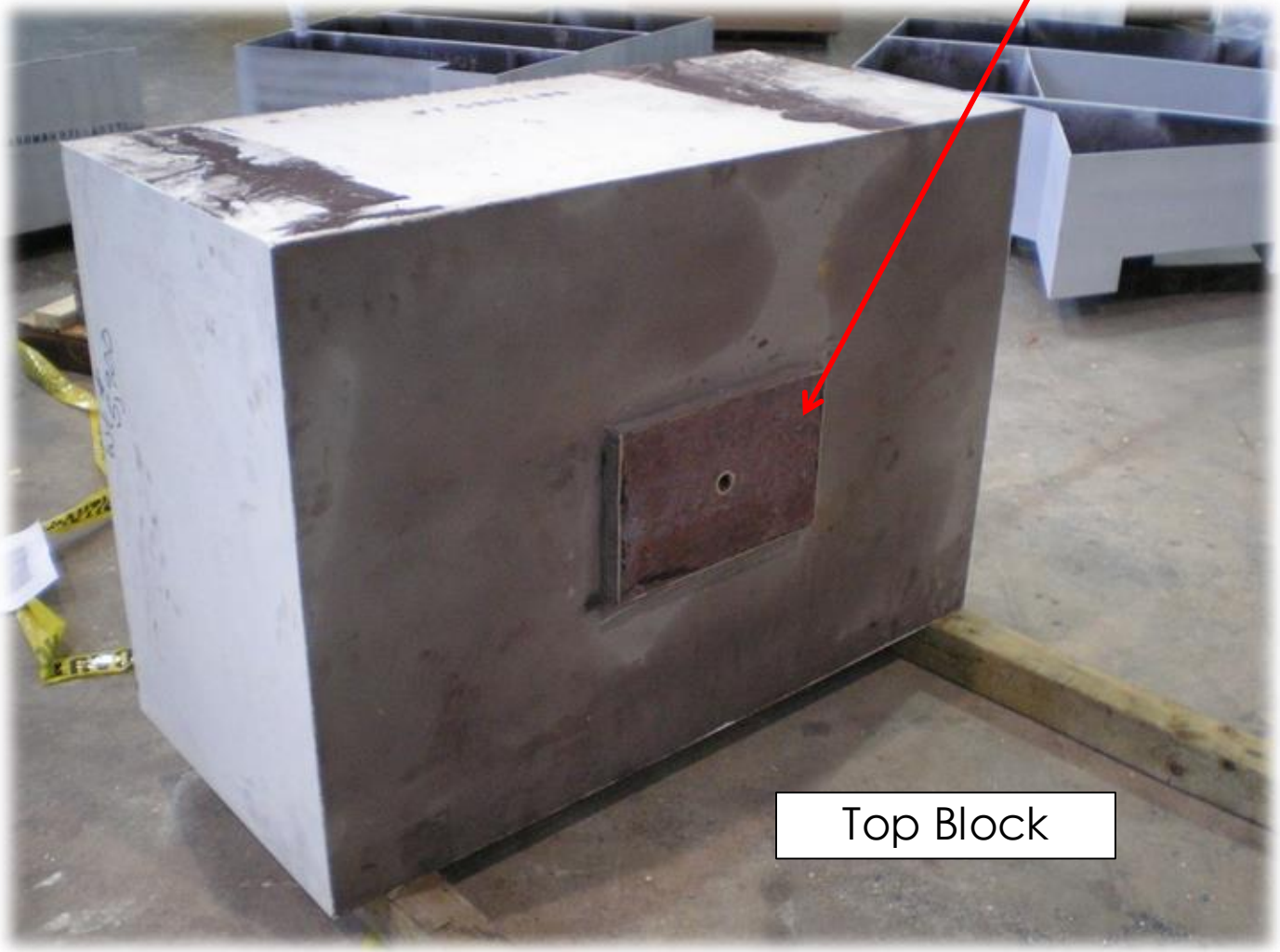
- George investigates, and finds photographs taken during the original installation of these blocks
- The blocks were designed to be stacked upon the installation fixture, and then be pushed into place on cam rollers
- But the stack of blocks was larger than the hole
- So they started cutting the block

Concrete cutting

Concrete Cutting in 2007



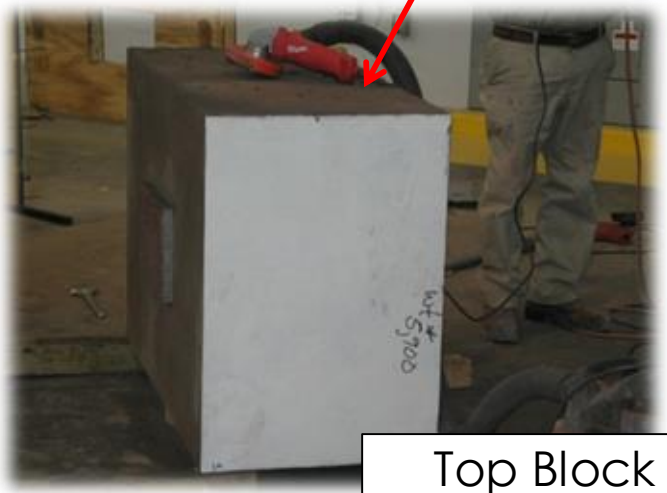
Cut #2 – part of the bottom face of the top block is removed



These photos were taken by the original installation team in 2007

More Concrete Cutting (2007)

Cuts #3 & 4 – both sides of the top block are cut



Top Block

Couterbore is completely removed, preventing installation of tie-down rod

Lifting eyes can be seen here before they were cut off

Cut #5 – the top ~40 mm is removed, including the lifting eyes, and the counterbore for the seismic tie-down

Top Block

These photos were taken by the original installation team in 2007

2007 Installation

The installation team drilled two new holes into the top of the top block (not pictured), installed drop-in concrete anchors, screwed in eye bolts, lifted the block into place, hammered the anchors down into the holes, pushed the three-block-stack into the monolith cavity, and left it

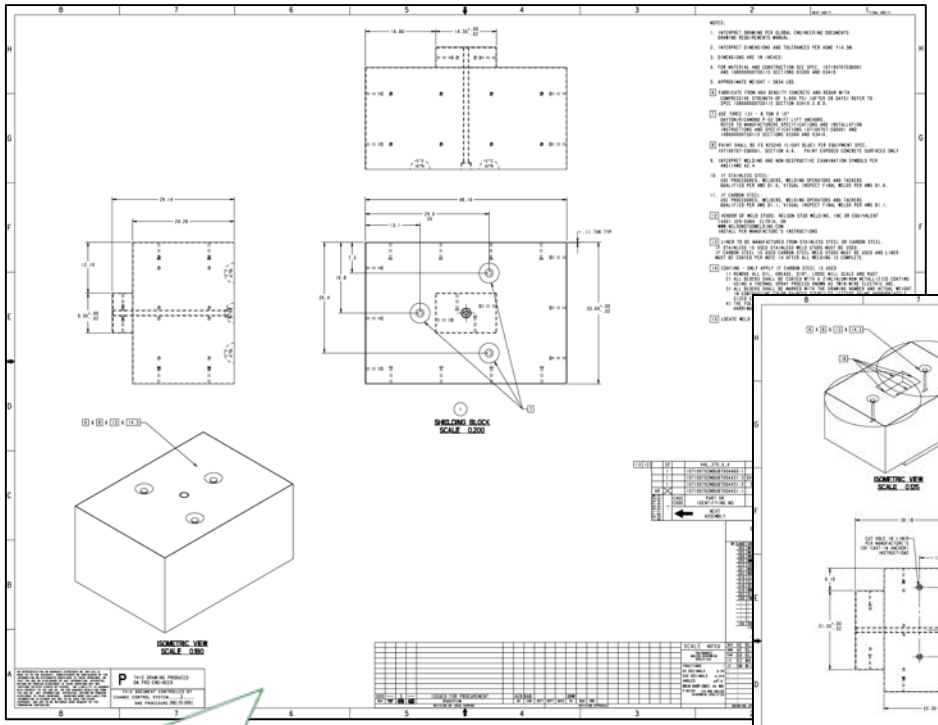
Riggers test lift the top block. The exposed High Density Concrete can be seen on the sides and bottom of the top block

The now painted blocks are pushed into the monolith cavity

These photos were taken by the original installation team in 2007

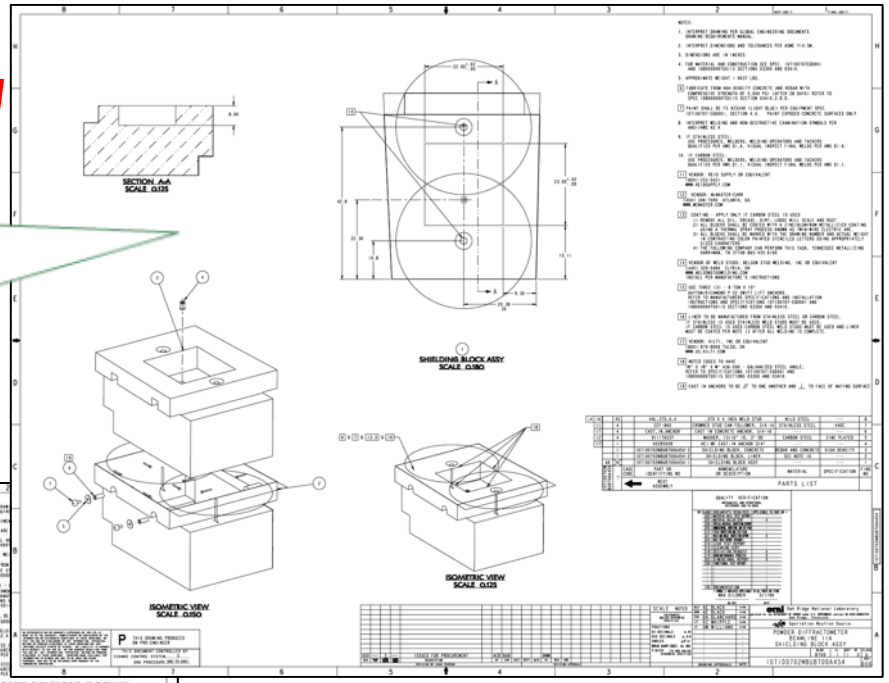
Configuration Management?

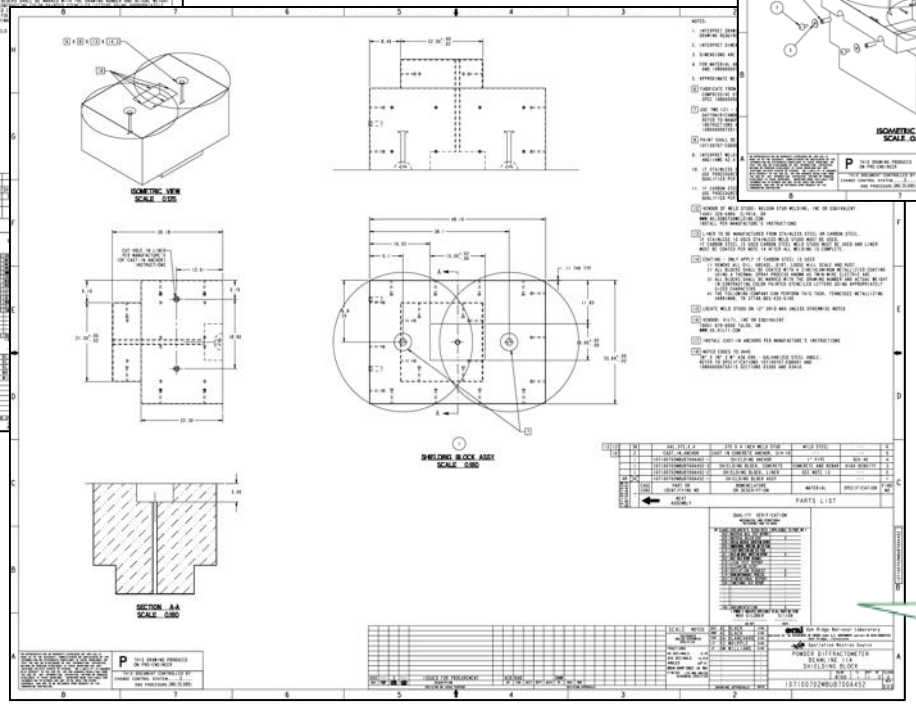
But the drawings are never updated



Top Block → Rev 00

Bottom Block → Rev 00



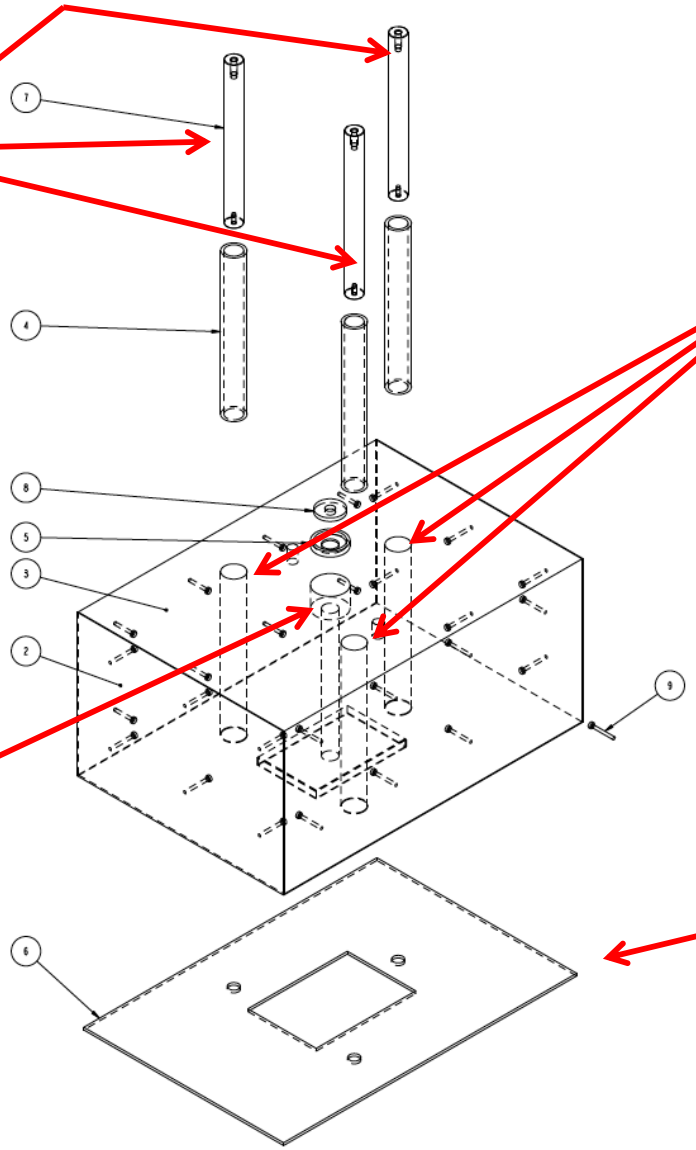


All drawings are still at Revision 0 at time of T0 Mount Upgrade Installation!

Middle Block → Rev 00

Top Block Modification (2018)

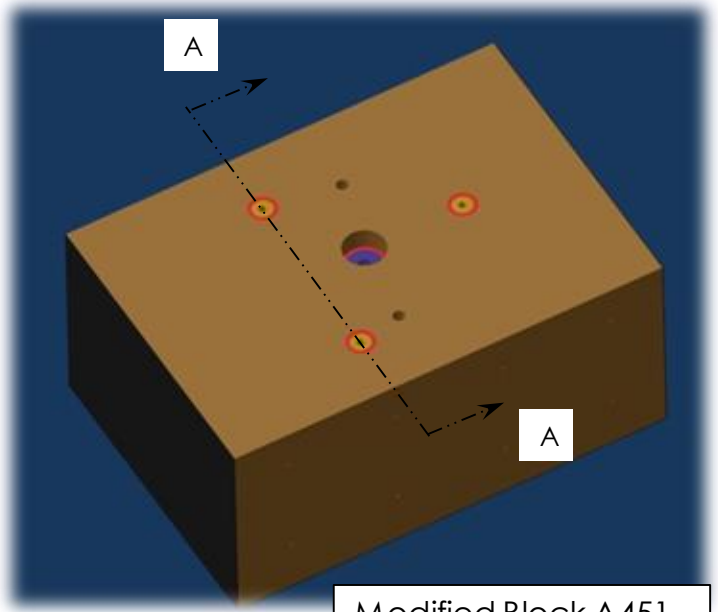
3 rods installed in new core-drilled holes, and are epoxy grouted in place



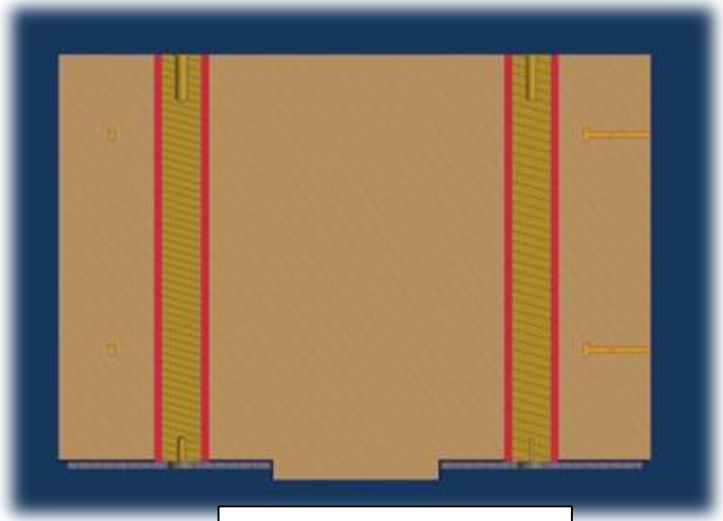
3 new holes were core drilled into the existing block for lifting

4th hole core drilled with counterbore for tie-down rod

Rods are welded to new 3/8" (~10 mm) plate, which is welded to existing can



Modified Block A451



Section AA

Top Block Modification (2018)

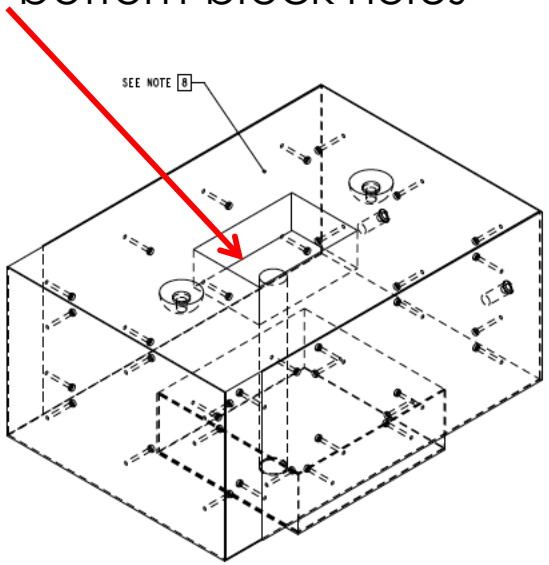
3 new holes were core drilled into the existing block for lifting

4th hole core drilled with counterbore for tie-down rod

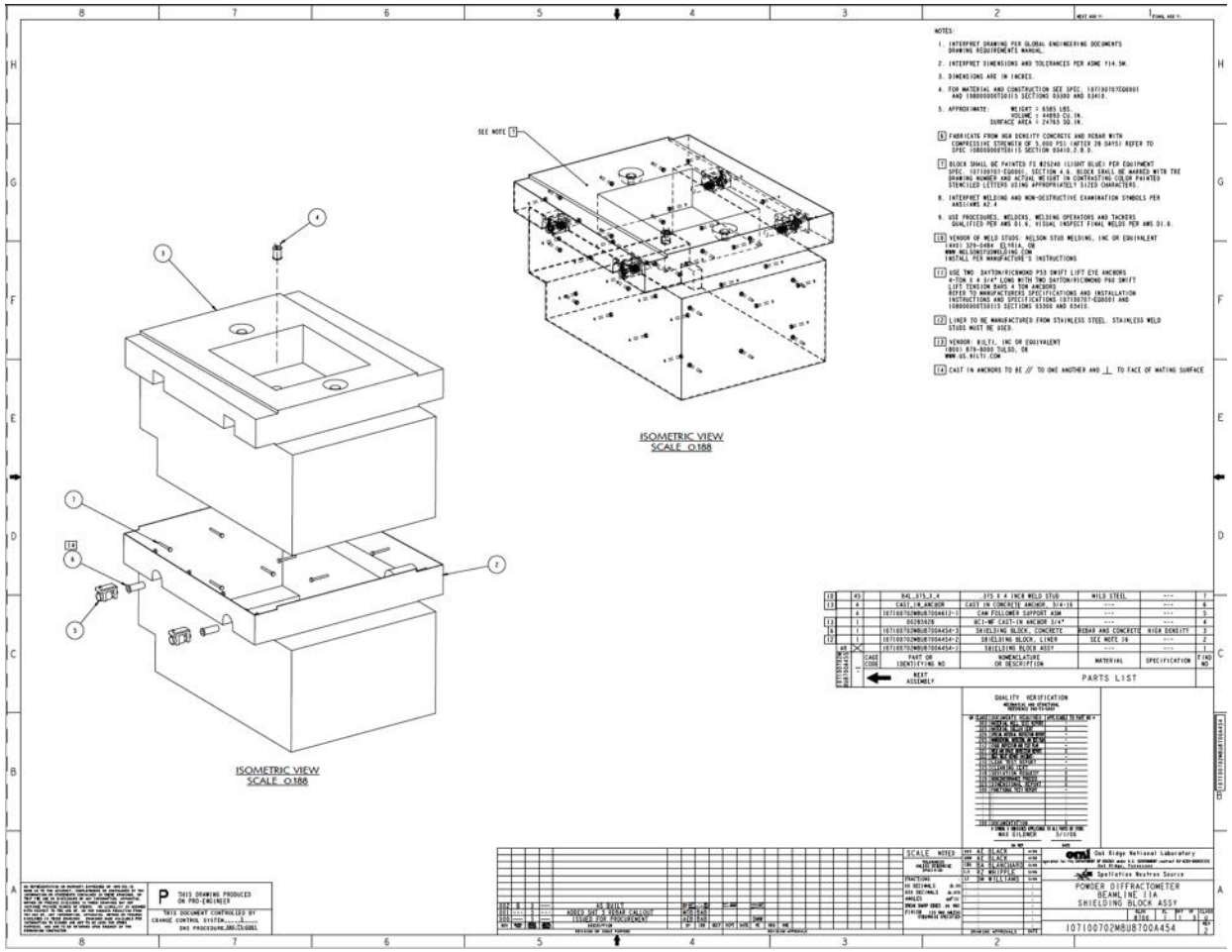
Completed block modification
Threaded insert rods installed and base plate welded in place

Middle and Bottom Block Modifications (2018)

Middle block was modified to have a larger tie-down hole core-dilled, because old hole did not align with top and bottom block holes

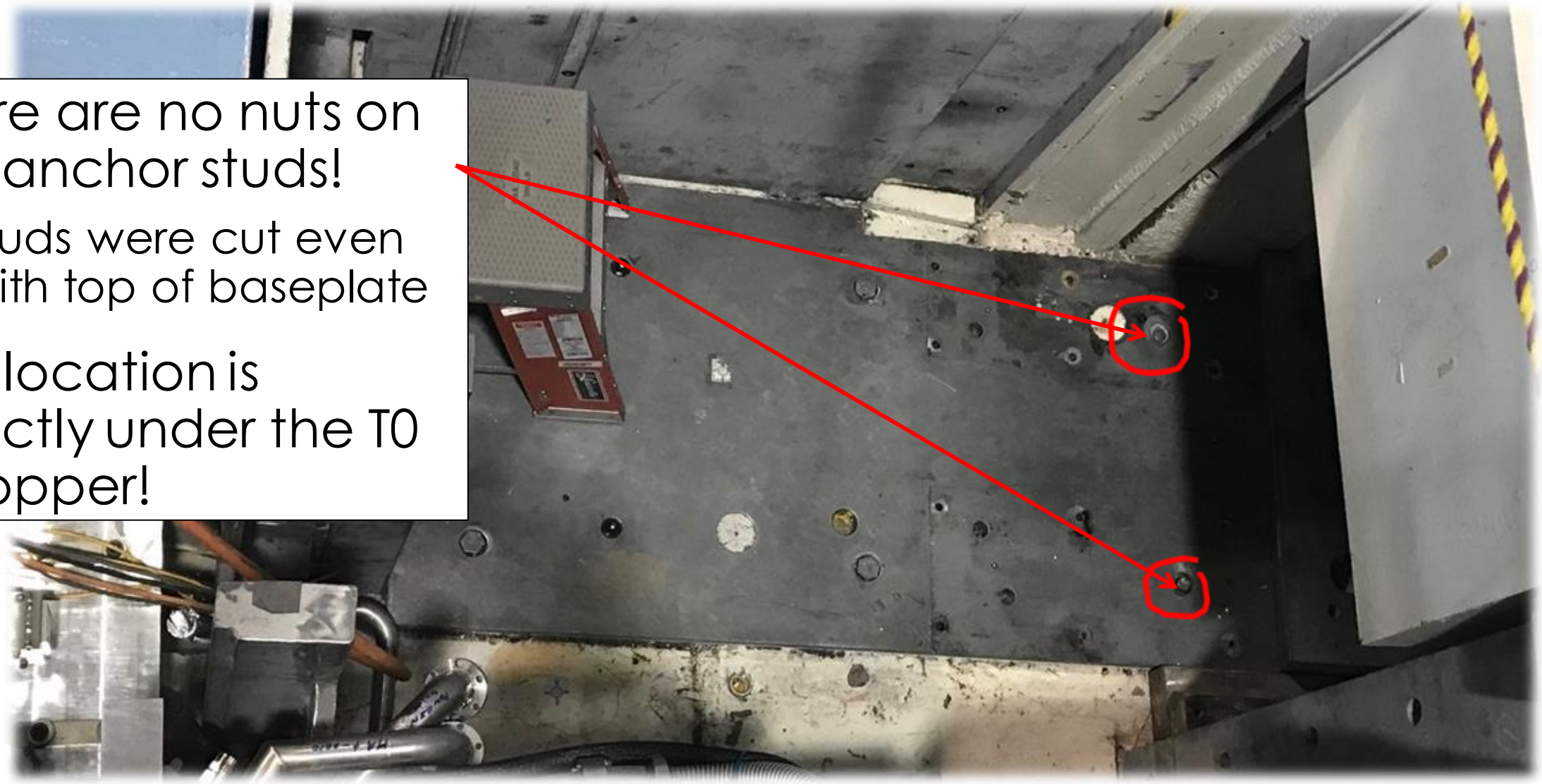


Bottom block drawing is revised to reflect as-built (as-found?), as-installed in 2007



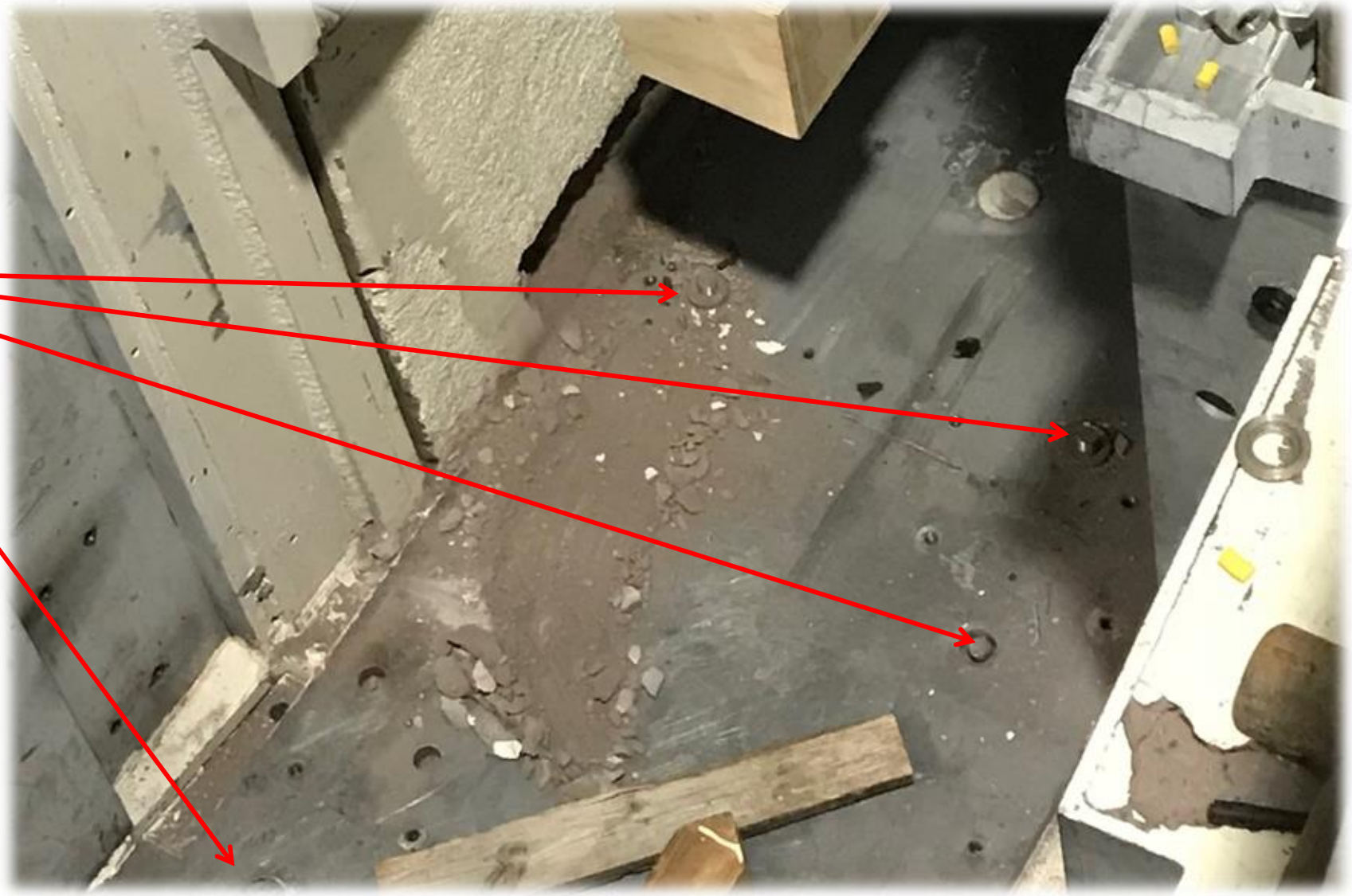
Surprise Number 4 – The Biggie!

- There are no nuts on the anchor studs!
  - Studs were cut even with top of baseplate
- This location is directly under the T0 Chopper!

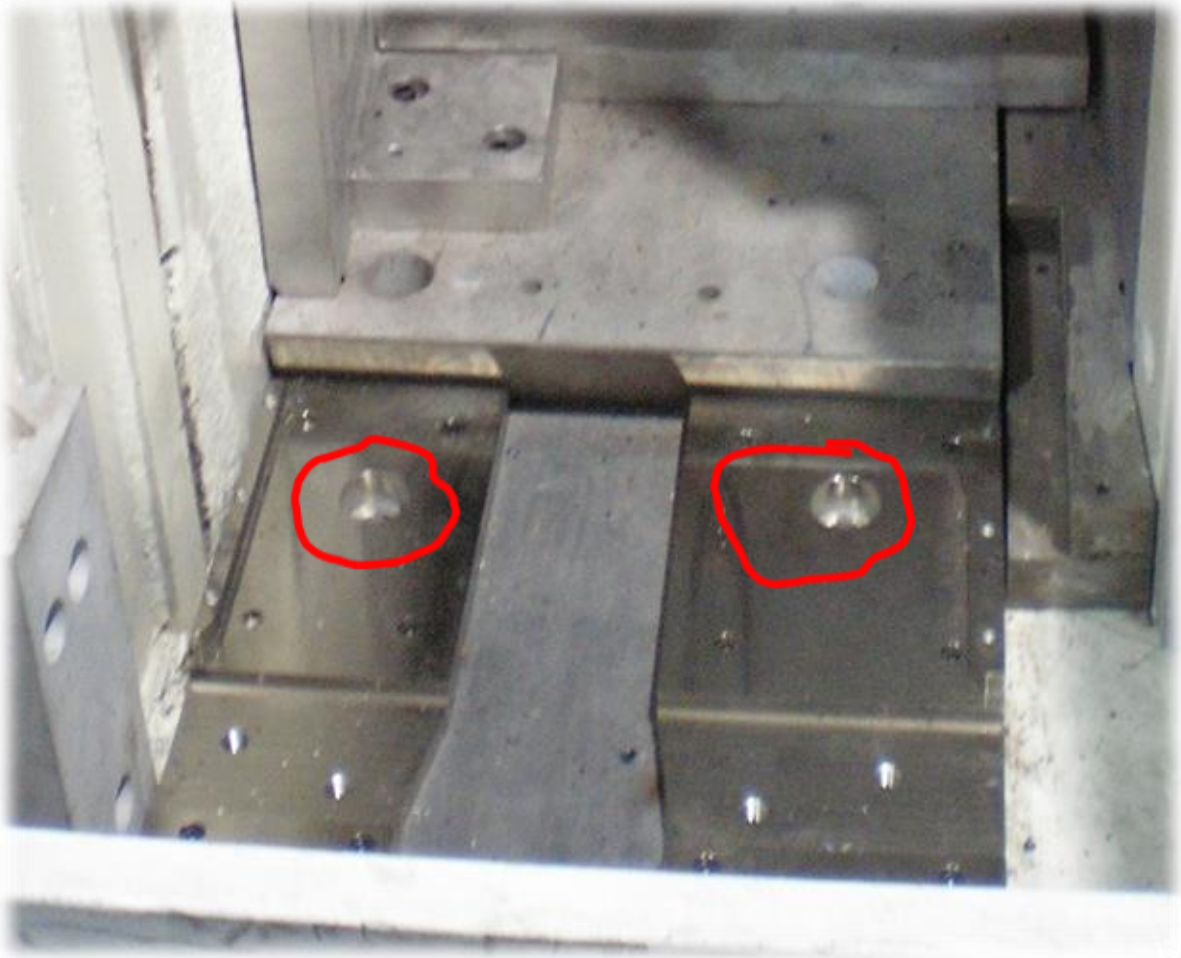


Embed Plate Removed

All anchor studs appear to be the same size, although holes in plate are 2 different sizes



2007 Installation Photos (no nuts)



2018 Demolition Continues…

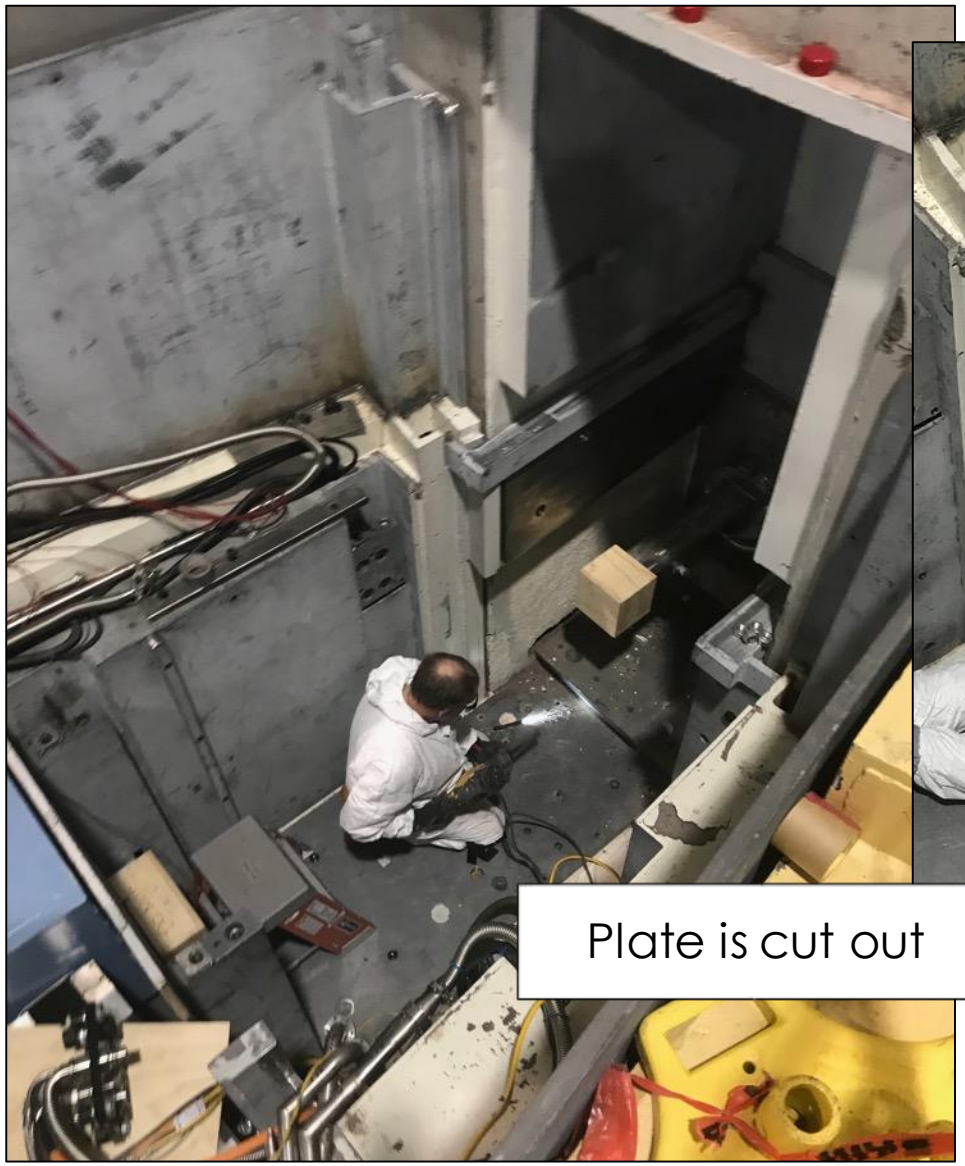
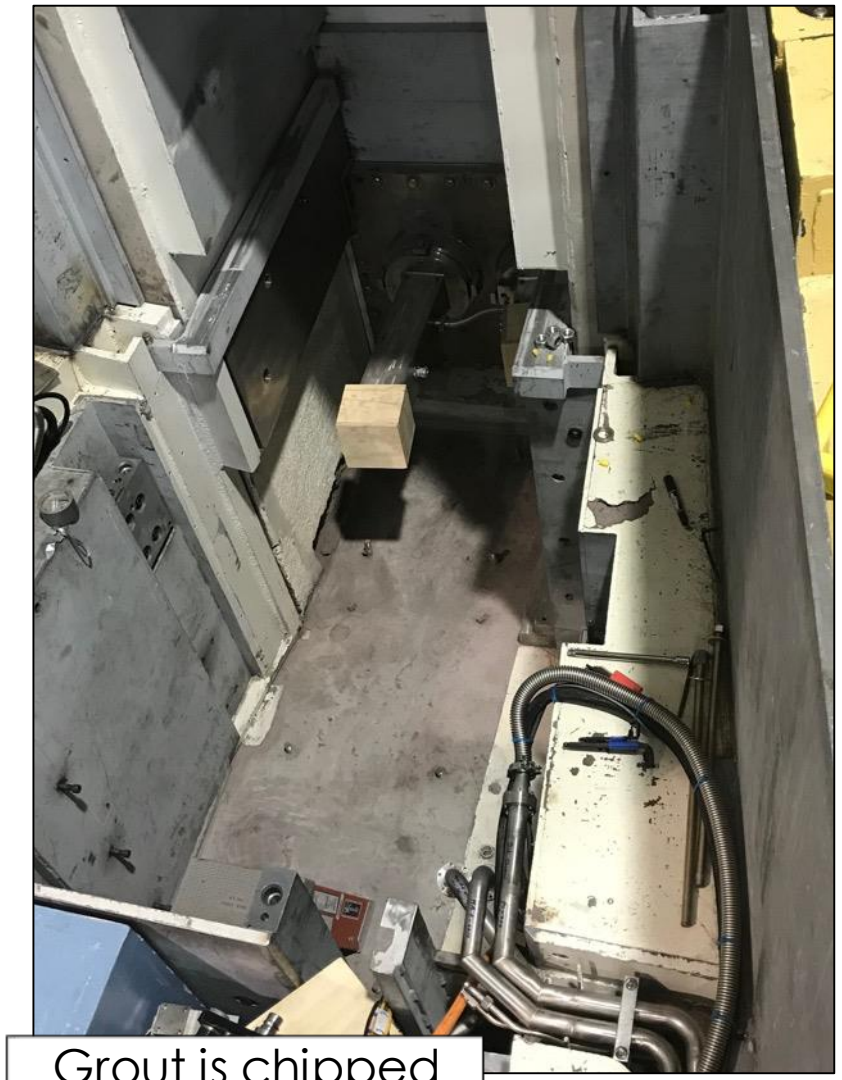


Plate is cut out



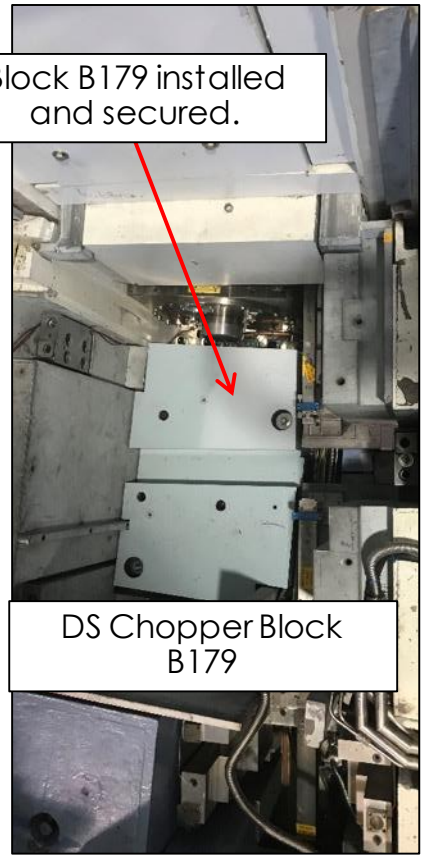
Grout is chipped away

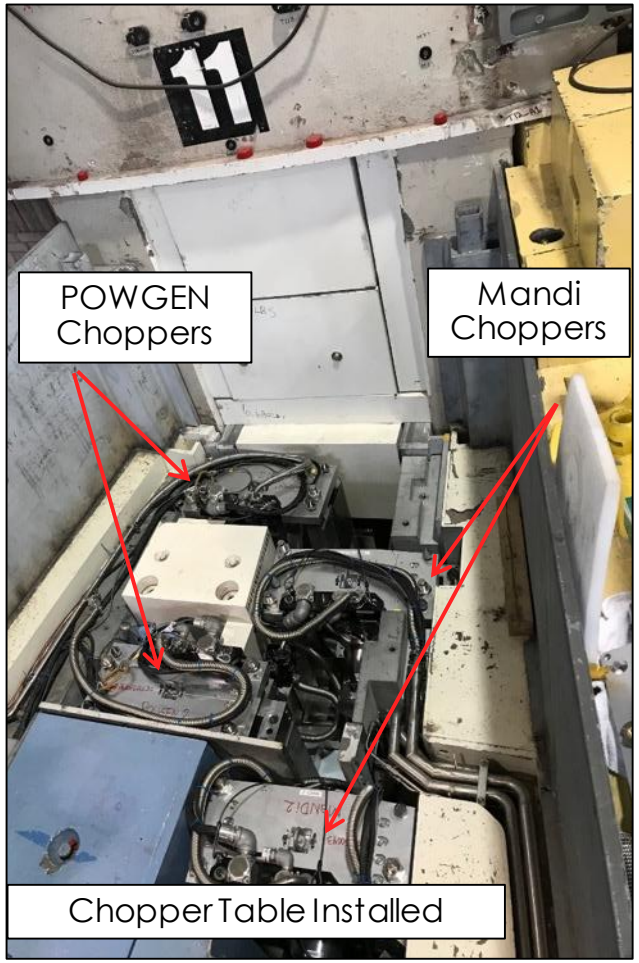
New Plates Are Installed

plate is set

grout is placed

Installation goes much more smoothly

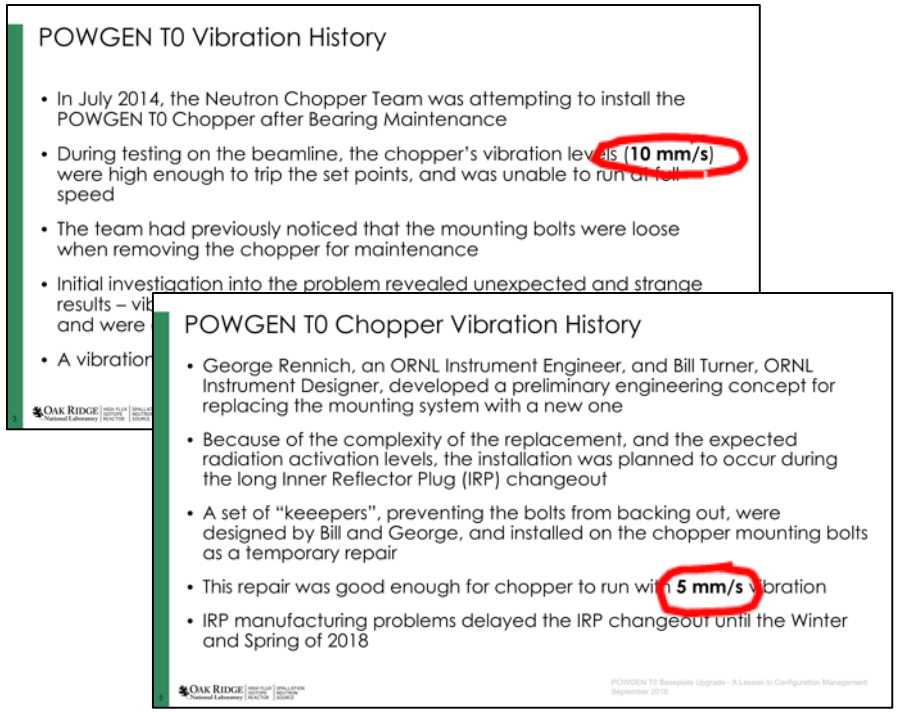


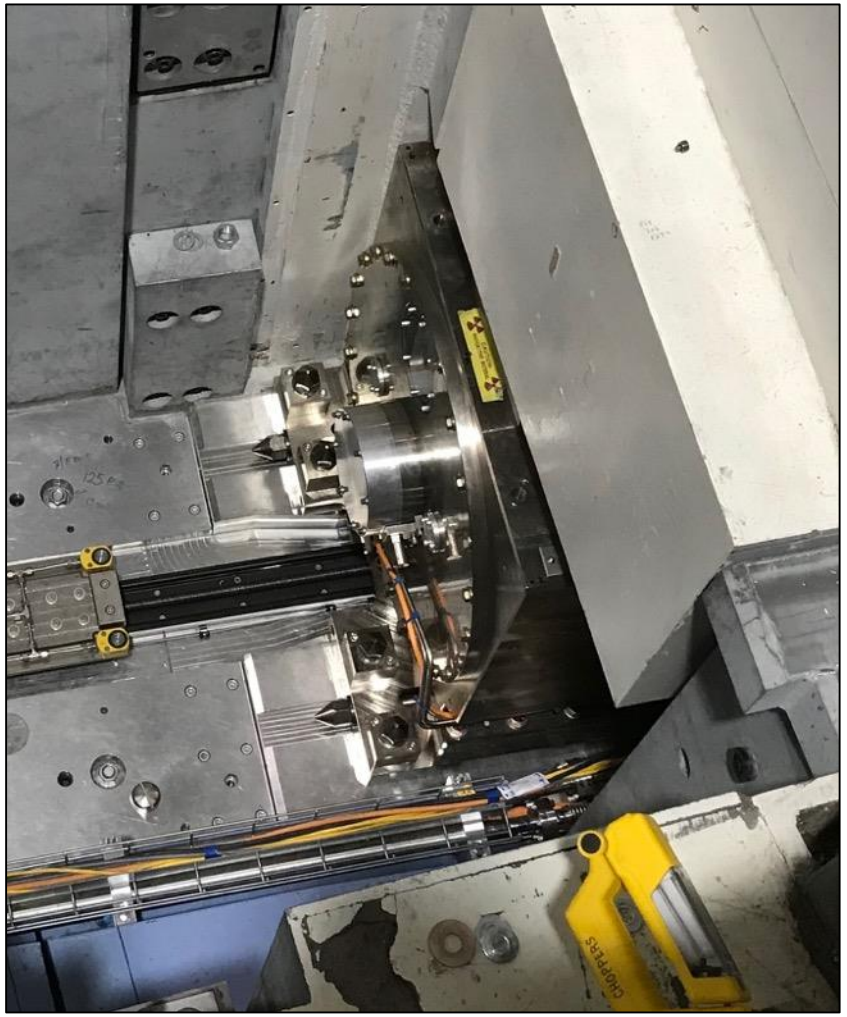


Installation Complete!

Results

- Full Speed Testing Of POWGEN T0 Chopper mounted to new baseplate design results in **0.7 mm/s** vibration
- We started at 10 mm/s and got to 5 mm/s with temp fix





POWGEN T0 Chopper Installed on new mounting plates

Conclusions

- Poor configuration management from the original installation cost $ x 10^5 a decade later
  - As-built drawings are important
  - It is ***never*** OK to hide your mistakes
- This upgrade *could not have been completed* during a normal outage
  - If the problem had run to failure, the beamline, and its neighbors would have lost at least one entire run cycle
- Photos taken during the original installation were invaluable
- The repair would have been a magnitude more difficult if not for the quality of the people doing the redesign and installation