Radiation Transport Target Design and Build

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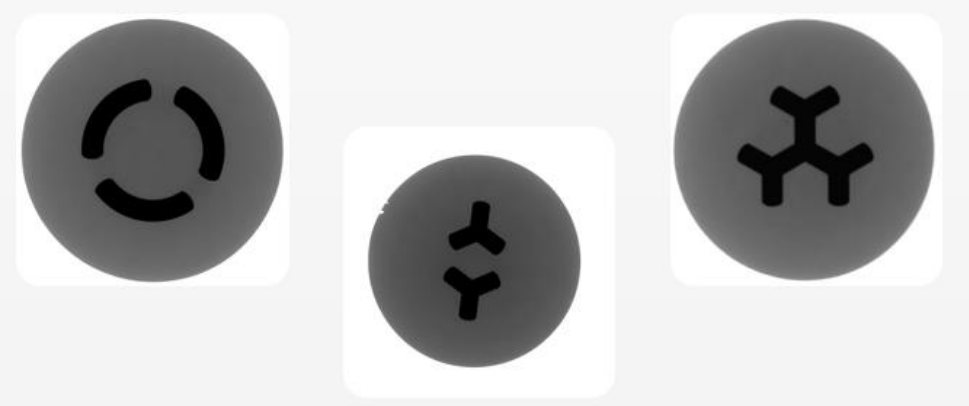
23rd Target Fabrication Conference, April 2019



Radiograph images of AWE TFG manufactured Rad T physics packages

Presenter: Nigel Martin; Presentation: Greg Lilleystone

Radiation Transport Target Design and Build

AWE Target Fabrication has been working closely with their LLNL counterparts to produce the latest targets for a UK-led series of experiments to study radiation transport through materials. Building on the previous “Searchlight” series of experiments, the effect of radiation transport through tantala aerogel discs is being investigated at the National Ignition Facility at LLNL.

AWE and LLNL TFG team members during October 2018 visit to AWE TFG.

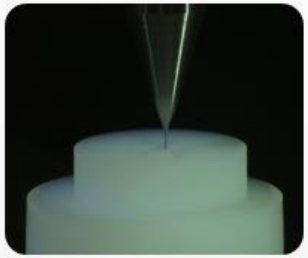
Radiation Transport targets comprise a halfraum driving a physics package incorporating a tantala aerogel disk machined with a series of patterns.

Rad T NIF campaign introduction

During 2017 and 2018 AWE and LLNL TFG (as part of the Rad T collaboration stage 1) worked together to ensure that AWE TFG could produce the physics packages independently. This required new skills and capabilities.

Physics package process steps:-

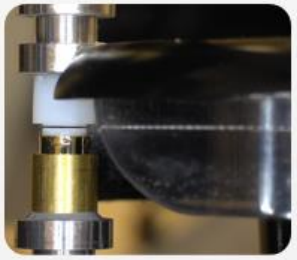

Tantala aerogel manufacture


3'Y' shape being machined.

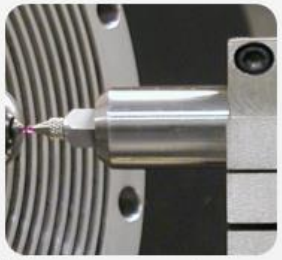

Gold washer, manufacture


Ta foam end face diamond turned.


Ta foam bonded onto gold washer


Slitting saw parts off surplus material


Ta foam end face diamond turned


Measurement on machine.


Characterisation: including radiograph


Packaged in shipping fixture

Current progress

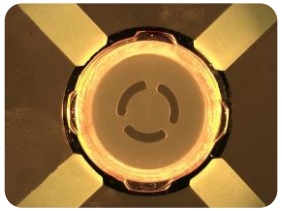
Over the last 18 months AWE TFG (Target Fabrication Group) have supplied physics packages made with AWE components. This has included existing milled shapes but also new ones such as the “3Y". Key challenges in manufacturing slots in tantala foam is to retain sharp edges (no chipping!).

AWE TFG have supplied to LLNL the following sub assemblies (ta foam machined to size and bonded onto gold washer):

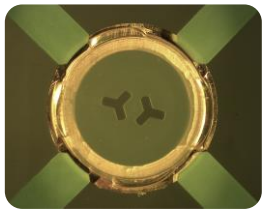
2 x nulls, 2 x 1Y
9 x 2Y, 5 x 3Y
3 x 3SL, 2 x 3S
2 x 3SR

“3Y” physics package

“3S” physics package



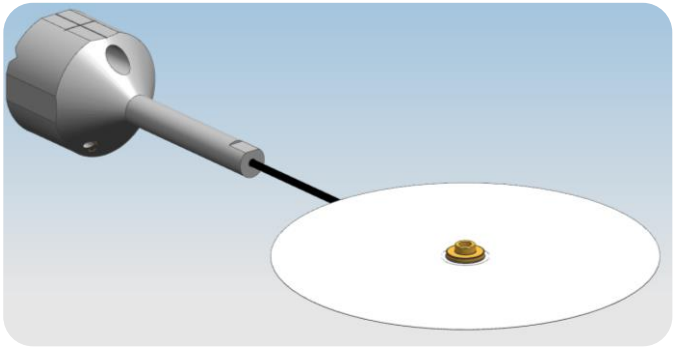
“2Y” physics package



Photographs of AWE TFG manufactured Rad T physics packages mounted on the shipping fixture

Rad T NIF target assemblies.

With stage 1 complete, stage 2 was for AWE TFG to assemble the full up Rad T NIF targets. This again required new capabilities, the purchase of capital equipment and corresponding training to be put into place.



Calorimeter target assembly image

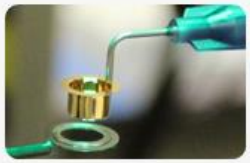
In October 2018 LLNL visited and trained AWE TFG assemblers to build and measure full NIF targets that were successfully shot at NIF in April 2019.

New AWE TFG capability - our new OGP's!

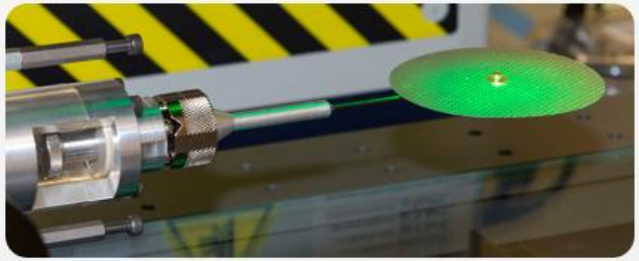
AWE TFG have recently invested in a new OGP to enable the assembly of the Rad T targets. The OGP has a 0.5 times objective and has an increased bridge. It comes with the latest version of measure mind but also with the new zone 3 software (this allows the importing of cad models).

Mark Lightfoot & Ian Winter working on a Rad T target

Assembling the shield



Assembling the hohlraum

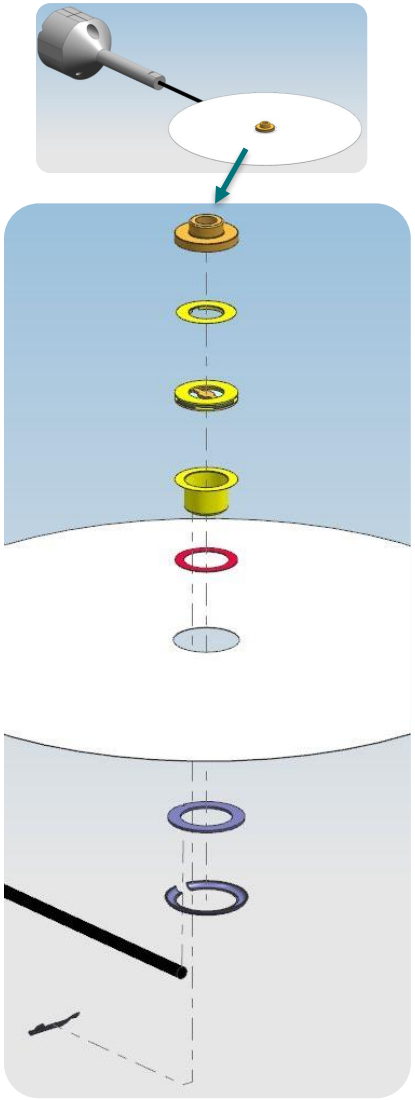


Calorimeter target assembly

Rad T NIF target assemblies.

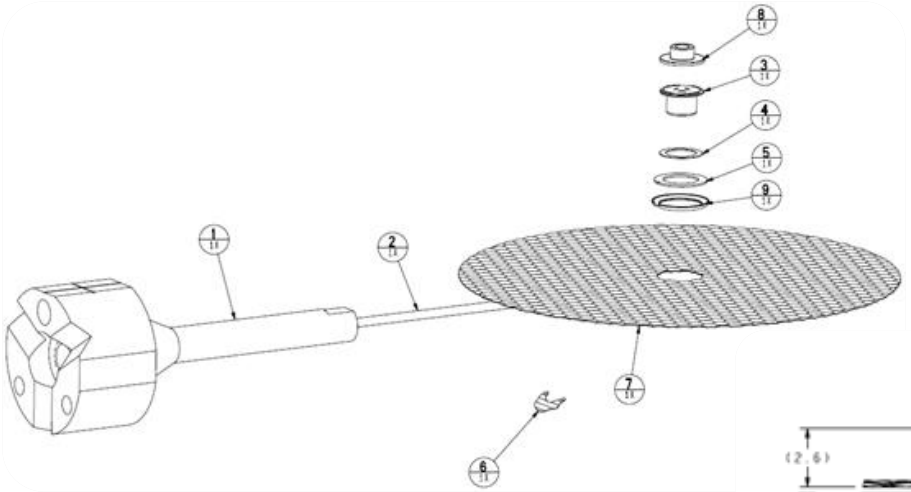
- Stage 3 of the target assemblies is for AWE TFG to manufacture the specific target components where possible. Currently LLNL TFG are providing these components.

- AWE TFG are currently investing into improving their capability and supplier base for hohlraum manufacture.



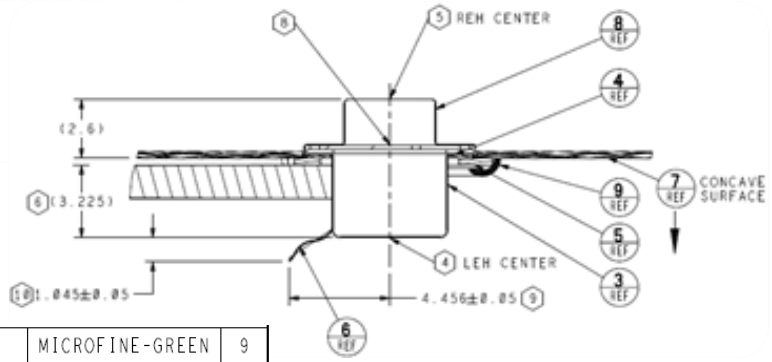
Exploded image of calorimeter target

Rad T target types - Calorimetry



Exploded drawing view of calorimeter target

3 targets built and supplied in October 2018 to LLNL, successfully shot at NIF in April 2019.



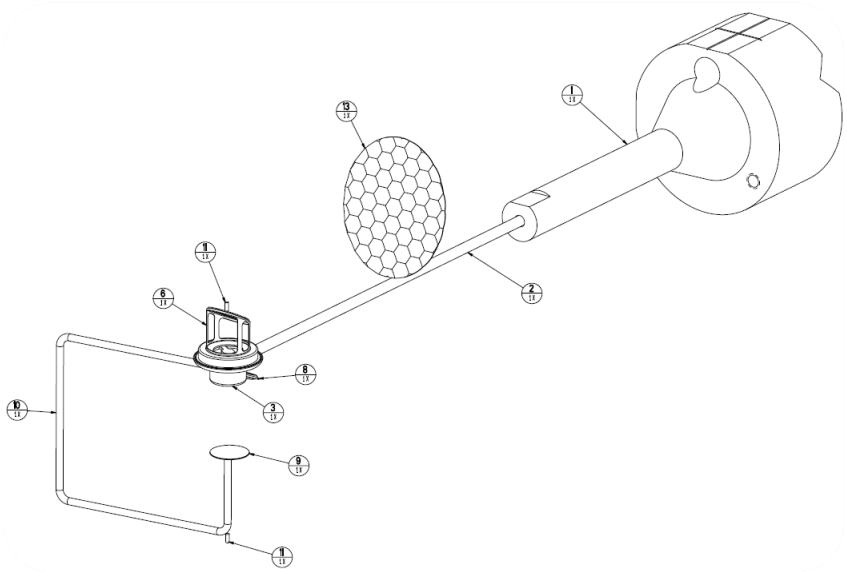
Cross section detail view of main components

QTY REQD	IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO
1	1002749833	TORUS, SHIELD, LOWER	MICROFINE-GREEN	9
1	1002757146	CALORIMETER HOHLRAUM	GOLD	8
1	1001865262	RADT_AWE UNC LIGHT SHIELD	-	7
1	1004067078	FORMED, SHIELD, DANTE2	TANTALUM	6
1	AAA14-500770	SUPPORT RING	SILICON	5
1	AAA09-500815	PHYSICS PACKAGE SPACER	CH	4
1	1005225609	RADT_AWE TRI-2w PHYSICS PACKAGE	N/A	3
1	AAA15-108273	ROD, TARGET SUPPORT, 1.5 DIA X 80	CARBON FIBER	2
1	1002270669	TARGET BASE, STANDARD	AL 6061-T6	1

PARTS LIST

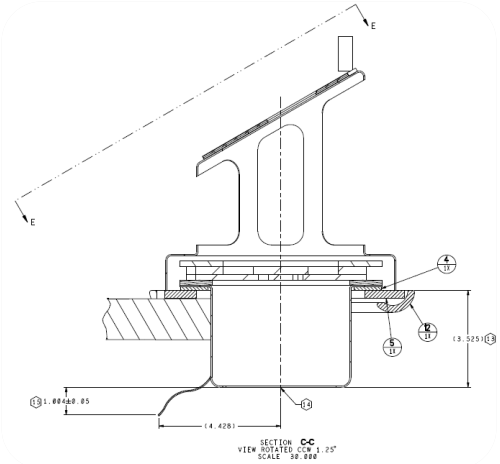
Bill of materials for calorimetry target assembly

Rad T target types - Radiography



Drawing view of radiography target

On track to build and supply to LLNL 2 targets in April 2019.



Cross section detail view of main components

QTY REQD	IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO
1	1004128105	COATED, SHIELD, DANTE, 17 X 20	N/A	13
1	1002749833	TORUS, SHIELD, LOWER	MICROFINE-GREEN	12
2	AAA15-104144	ROD, ALIGNMENT, 0.5 DIA X 1.25L	FUSED QUARTZ	11
1	1002663837	SUPPORT, COATED	N/A	10
1	1002402040	ASSY, BACKLIGHTER	N/A	9
1	1004067078	FORMED, SHIELD, DANTE2	TANTALUM	8
1	1005452515	MASK, COATED, LAB	N/A	7
1	1005588034	COATED, RADT MASK SUPPORT	N/A	6
1	AAA14-500770	SUPPORT RING	SILICON	5
1	AAA09-500815	PHYSICS PACKAGE SPACER	CH	4
1	1005588112	RADT WINDOW 2Y HIGH DENSITY PHYSICS PACKAGE	N/A	3
1	AAA15-108273	ROD, TARGET SUPPORT, 1.5 DIA X 80	CARBON FIBER	2
1	1002270669	TARGET BASE, STANDARD	AL 6061-T6	1

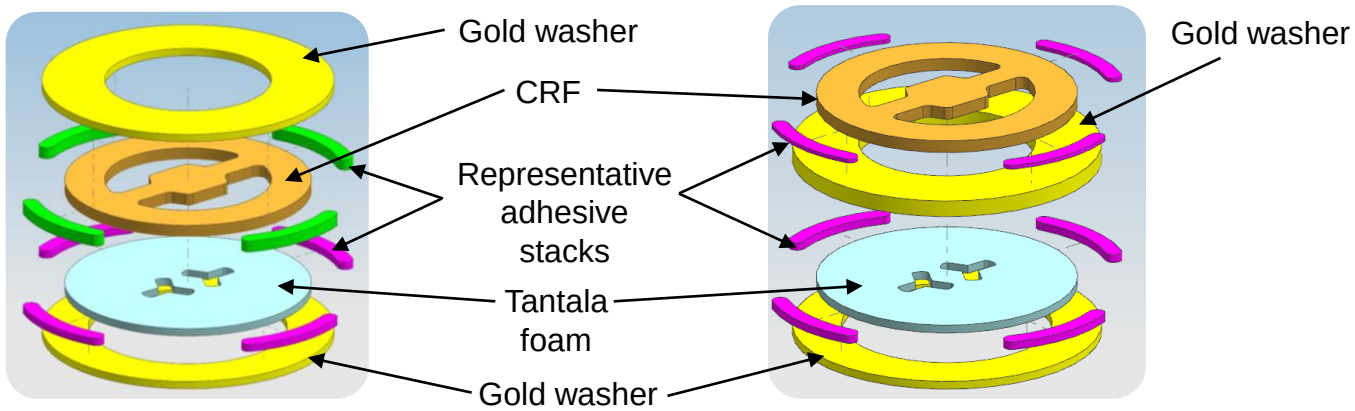
PARTS LIST

Bill of materials for radiography target assembly

Due to concerns with potential damage due to shipping the back lighters for these targets will be built at LLNL.

AWE specific physics package design

Now that AWE have reconfirmed and evolved the current configuration of physics package design and proven this through the NIF shots the next step was to develop this further with the window design. This design will investigate the interaction between contrasting materials and uses different densities of CRF (Carbonised Resosinol Formaldehyde) and has 2 subtly different design types.

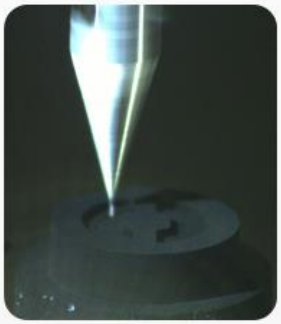


Physics package Medium or High densities (80 or 240 mg/cc CRF) type 1.

Physics package Medium density (80 mg/cc CRF) type 2.

Window design challenges

Manufacturing challenges in working with the crf with complex shapes and thicknesses of 0.3 or 0.1 mm.



Photograph of the profile milling into the crf

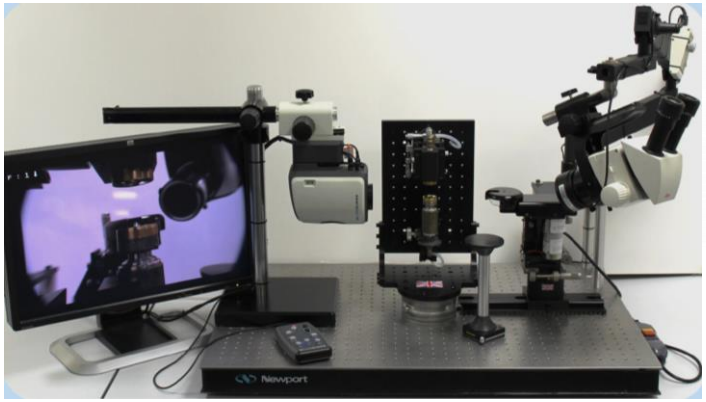
Photograph of crf profile bonded onto the gold washer

Photograph of adhesive wicking into the material

Photograph of fracture into the material

Photograph of 6 axis micro load cell

Due to the CRF's appearance it is difficult to visually see when actual contact is made with the gold washer. To improve assembly we have added a micro load cell to our existing assembly station and are in the process of proving it out. The purpose is that the load cell will detect when contact is made of the mating components.



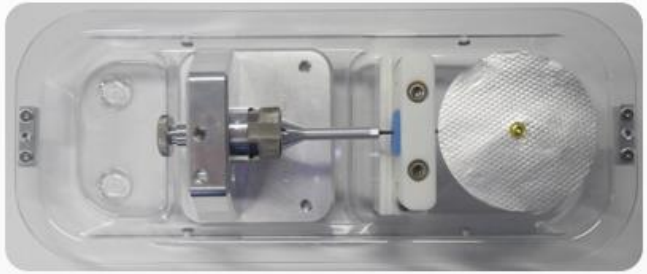
Photograph of the current assembly station set up

Challenges of shipping!

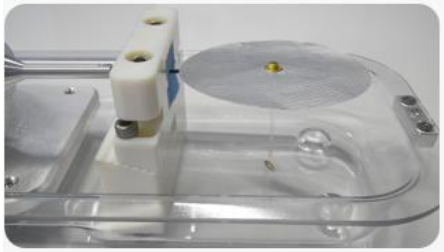
As mentioned on our poster, a large challenge for the Rad T campaign is ensuring that target components and target assemblies will be able to survive shipping across the pond.

We have done many trials with LLNL and have designed and built specific fixtures for the physics packages and the full targets as shown below.

Currently targets are shipped commercially and we ensure the boxes are heavy duty and full of interlocking packing foam to absorb any shocks or loadings.



Photograph of the calorimeter target assembly in target box with transportation fixture.



The fixture has grooves to allow for tension adjustment and foam to absorb shocks.

Photograph of the packing box complete with shock and tilt indicators.

New facilities at C17 – Machining

Benefits of the new workshop will be:

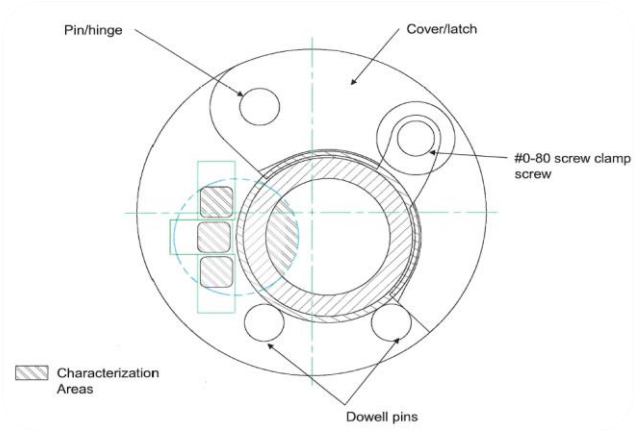
- A dedicated precision machine shop containing 2 diamond turning machines and a multi axis diamond milling machine. This will greatly improve process throughput.
- An adjoining general workshop containing CNC (computerised numerical control) mill and lathe which will accelerate the manufacture of jigs and fixtures, currently made in other facilities / off site.
- For the assembly room having an ISO class 7 clean room will be a huge step in improved capability and quality.

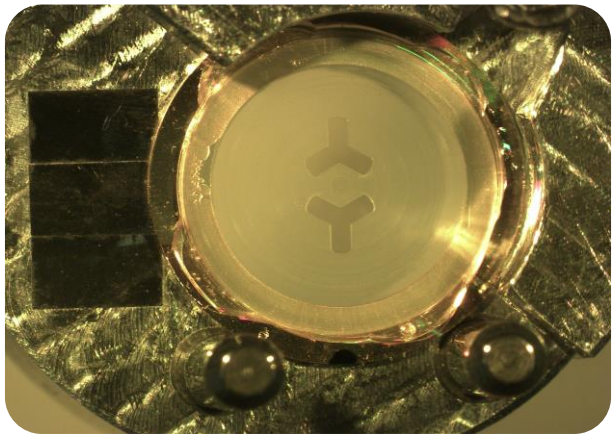
Physics package characterisation

A key part to the campaign is having a good understanding of the measurements and properties of the physics package, this is key to understanding the shot results.

The dimensions of the shape cut outs are measured by a vision CMM (co-ordinate measuring machine) at the milling stage and completion.

The density of the foam is achieved by radiographing the foam alongside reference tantalum foams. Currently this is based on a LLNL made artefact that has 3 reference foils of known thicknesses.



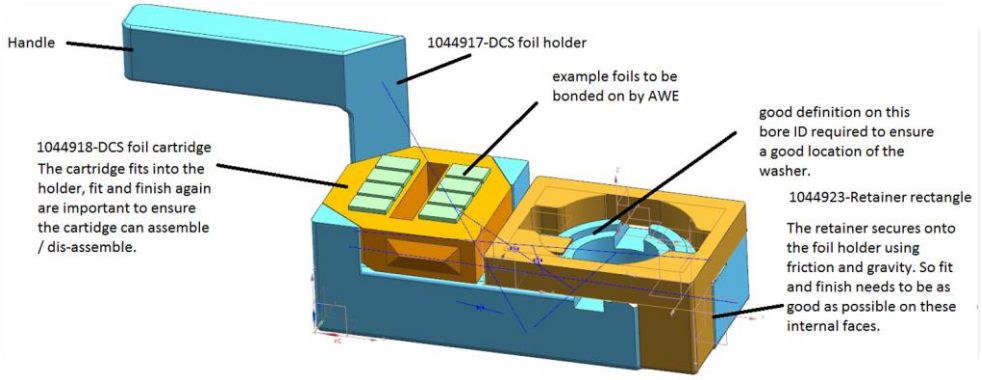


Drawing and photo of the LLNL artefact with tantalum foils

New kit for characterising the foam density

AWE are in the process of purchasing a density characterisation system (DCS) designed and built by LANL. This is a mono chromatic x ray system with interchangeable source heads which we anticipate will characterise the tantala foam density to a high accuracy (currently performed by radiography).

TFG are supporting with the design and manufacture of this tantala foam holder and the tantalum reference foils supported by LLNL TFG.



Annotated image of the DCS holder

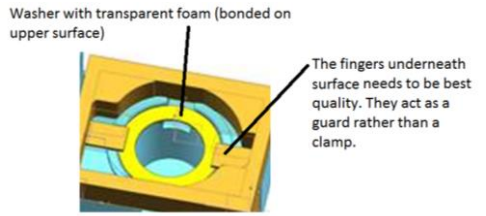


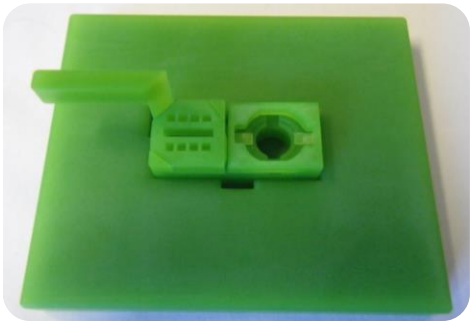
Image showing the gold washer retained by the holder top clamp.

Radiograph artefact development

The fine line green part has been now made and performed its function as part of the factory acceptance tests for the new DCS at LANL recently.

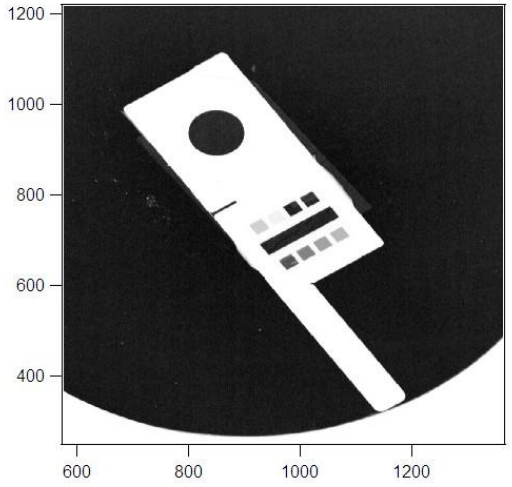
Next steps are to prove out the design and manufacture reference null Ta foams.

AWE TFG are planning to use this same characterised foil cartridge and design a new holder that can be mounted vertically so it can be used on the existing x-ray equipment.



Photograph of the DCS holder in handling and loading tray.

Photograph of the test al reference foils bonded onto the cartridge.



An image from current radiography equipment of the holder and al foils.

Rad T next steps

- To be fully operational in new facility with existing and newly acquisitioned equipment.
- Plan for future target designs, based on NIF shot data .
- Continue to develop capabilities in the building of Rad T target assemblies, the goal is to ship targets complete with back lighter sub-assemblies.
- Manufacture ta foam at a reduced density of 325 mg/cc or reduced thickness (0.12 mm).
- Manufacture, where possible, the sub components for the Rad T target assemblies.
- Develop capabilities on in-house hohlraum manufacture capabilities.

Summary

So far the collaboration with LLNL has been very fruitful in terms of the progress we have made in the production of the Rad T physics packages and now the assemblies. The challenge is to maintain this level and increase capabilities to meet our future objectives.

We would like to thank the following people for their help and contribution to the Rad T programme:

AWE TFG personnel:-Ryan Bedford, Gareth Cairns, Sav Chima, Shelley Cole, Ian Hayes, Mark Lightfoot, Greg Lilleystone*, James Lockyer, Nigel Martin, Paul Maslin, Russ Merritt, Mike Norman, Sam Pearce, Leigh Reed, Steve Siarey, Luke Urry, John Webb, Ian Winter

AWE physicists:-Warren Garbett, Peter Graham, John Morton, Mike Rubery.

LLNL TFG personnel:-Matt Arend, Dawn Lord, Rick Vargas, Johnathan Ward

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