# INTDS

## Newsletter

International Nuclear Targets Development Society

Carrousel holding $^{238}U$ thin layer targets prepared by physical vapour deposition.
JRC Geel Target Preparation Laboratory, European Commission, Joint Research Centre (JRC), Geel, Belgium

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# Contents

# Editorial

Dear INTDS Members,

In this edition of Target Laboratories of the World, we are pleased to feature the Target Preparation Laboratory at the Joint Research Centre in Geel, Belgium. Their group leader, Goedele Sibbens, presents an inside look at their work. Take a moment to admire the beautifully prepared thin layer targets of $^{238}U$, produced via physical vapor deposition and visible in our title image.

We also have some updates from the INTDS Board. Please join us in congratulating Kristian Myhre (Oak Ridge National Laboratory), who has been appointed as our new Assistant Webmaster. He will be working alongside Anna Stolarz (University of Warsaw) to help keep the INTDS website current and informative.

It is with sadness that we announce the passing of Vera Yakusheva on March 4, 2025. Vera was a valued member of the Target Laboratory at GSI in Germany. Her dedication and skill as a target maker will be greatly missed. We extend our condolences to her family and colleagues.

Finally, we are excited to highlight a recent visit by Sir Martyn Poliakoff, popular chemist and youtuber, to the GSI Target Laboratory.

As always, we welcome your contributions to the INTDS newsletter! Whether it is ideas, announcements, ads, or topics you'd like to share with fellow target makers, please get in touch at INTDS-Newsletter@gsi.de.

Wishing you a summer filled with exciting experiments!
Best regards,
Birgit Kindler and Noemi Cerboni

# Target Laboratories of the World

JRC Geel Target Preparation Laboratory
European Commission, Joint Research Centre (JRC), Geel, Belgium
Goedele Sibbens

The JRC Geel Target Preparation laboratory produces tailor-made high-quality and well-characterized samples, called "targets". The targets are either freestanding or made of a material supported on a substrate. They are commercially not available, produced by state-of-the-art laboratory techniques and characterized in line with stringent quality criteria. The JRC is one of the very few providers world-wide that still has unique facilities and know-how in nuclear target preparation and characterization indispensable for nuclear data measurements. It is the JRC's mandate in the Euratom Treaty to establish a standard system of measurements. Nuclear reference targets are used by the beneficiaries in EU Member States and by international institutions at the respective accelerator sites to produce neutron-induced reaction cross sections and particle emission yields on key isotopes and reactions. These nuclear data are included in the libraries maintained by the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), the International Atomic Energy Agency (IAEA) Nuclear Data Services and others.
Target preparation has been carried out at JRC Geel since 1961 and was established for high-precision measurements of neutron-reaction data on site at the two large-scale neutron facilities and abroad at other accelerators. At a certain point in the nineties, these activities were discontinued and JRC Geel was partly "denuclearised", due to a reorganisation of the JRC activities. In the meantime, because of a renewed interest in "nuclear" and a prioritisation exercise, we refurbished some equipment, installed new equipment and can currently again prepare a limited amount of targets for nuclear data experiments. These targets are mainly used at the two accelerators on site, within the European research infrastructure for nuclear reaction, radioactivity, radiation and technology studies in science and applications project (EUFRAT), and at other nuclear sites within collaboration agreements or an EU funded project like Addressing PRiorities of Evaluated Nuclear Data in Europe (APRENDE).

## Target Preparation

Depending on the reaction being studied and the quantity being measured, we prepare targets with specific properties according to a suitable method. Radioactive and fissile material is handled within a nuclear controlled area inside a glove box in under-pressure dedicated to a specific isotope to ensure safety and avoid cross-contamination. In case the ingrowth of a daughter nuclide would interfere with the characterization or the neutron-induced reaction measurements, we purify the actinide material by ion exchange prior to the target preparation.

For neutron reaction cross-section measurements, in which the escape probability of the reaction product is strongly influenced by the target and/or the substrate thickness, we prepare thin film deposits with an areal density ranging from 10 to 400 µg·cm$^{-2}$ by two kinds of techniques: physical vapour deposition and molecular plating.

Physical vapour deposition is applied for $^{238}UF_4$, LiF, and Au layers by using resistive heating and for $^{235}U$ oxide and $^{10}B$ deposits using electron beams. The method is applied in different vacuum set-ups, dedicated to each material to avoid cross-contamination. The principle of this system is to evaporate or sublimate the starting material in a vacuum and condense the vapour on any kind of substrate. Aluminium rings are mounted as masks on top of the substrates and determine the requested area of the deposited material. The deposited thickness is monitored with a quartz crystal microbalance during the deposition process, see Figure 1. The technique can be applied in sequence in case of a multi-layer target.

Figure 1: (Left up) Loading $^{238}UF_4$ powder in the boat of the $^{238}U$ evaporator integrated in a glove box; (Right up) Rotating carrousel inside the 238U evaporator holding the substrates with their mask, and the quartz crystal as thickness monitor; (Left down) Layer of 99.998% $^{238}UF_4$ with an $^{238}U$ areal density of 48 µg·cm$^{-2}$ deposited on a stainless steel substrate by physical vapour deposition; (Right down) Layers of B with an areal density from 5 up to 75 µg·cm$^{-2}$ deposited on aluminium substrates by physical vapour deposition.

The molecular plating technique is based on the cathodic deposition of the actinide material onto a conductive substrate in an alcoholic solution. For each isotope of U, Pu, Am and Np, a molecular plating cell is designed and produced from polyacetal in the JRC Geel workshop according to the required dimensions of the substrate and the deposit, see Figure 2. The anode is a platinum grid rotating at a speed of 5 to 10 rounds per minute. The cathode is connected to a stainless steel holder, which contains the 10 µm or thicker aluminium substrate with on top an aluminium ring as mask that determines the effective diameter of the actinide deposit.

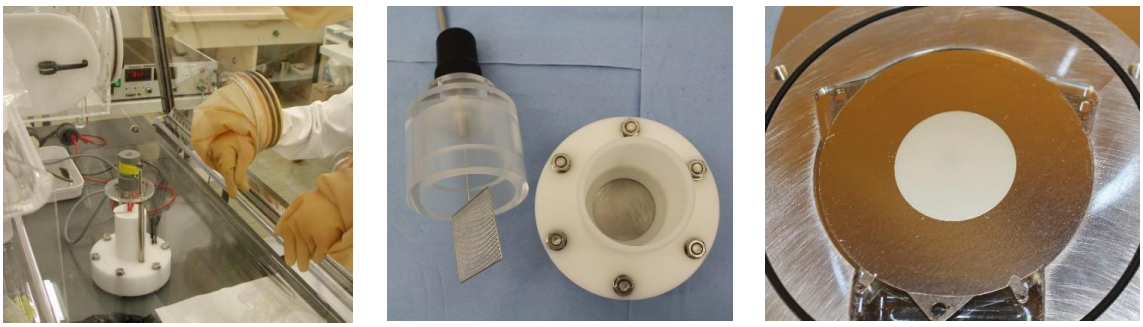

Figure 2: (Left) Molecular plating cell in a glove box; (Middle) Upper part of molecular plating cell with Pt anode and motor, and lower part in polyacetal with substrate as cathode; (Right) Layer of 99.9% $^{240}$Pu with a diameter of 33 mm and a $^{240}$Pu areal density of 66 µg·cm$^{-2}$ deposited by molecular plating. The substrate is a 0.018 mm thick aluminium foil stretched and glued on a 0.3 mm thick metal ring with inner and outer diameter of 64 mm and 74 mm respectively.

For the understanding of the nuclear fission process, we prepare spectroscopic targets to minimize the energy loss of the fission fragments when passing the deposited layer and the substrate. These targets are very thin $^{235}UF_4$ or $^{235}U$ oxide and $^{238}UF_4$ layers on 35 µg·cm$^{-2}$ polyimide foils whether or not covered with a 35 µg·cm$^{-2}$ gold layer for conductivity and are prepared by physical vapour deposition.
The targets for transmission measurements are covering a range of thicknesses and we apply mechanical techniques like punching metals and compacting powders by canning or by uniaxial pressing.

## Substrates

The aluminium substrates for neutron-induced reaction cross-section measurements are pre-treated to improve the adhesion of the deposited layer. We chemically etch the aluminium discs in a mixture of 80% $H_3PO_4$ + 4% $HNO_3$ + 16% $H_2O$. The thin aluminium foils, stretched and glued on an aluminium ring, are softly etched in a plasma, see Figure 3.

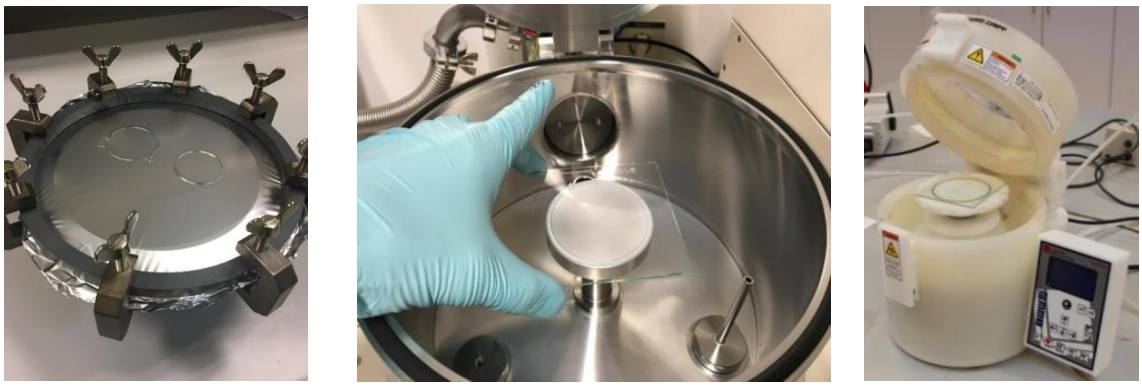

Figure 3: (Left) Stretching of an aluminium foil with a thickness of 10 µm and mounting on the aluminium rings by gluing; (Middle) Pre-treating a glass plate in a low-pressure plasma cleaner to increase the hydrophilicity; (Right) Spin coater to cover the glass plate with the polycondensate solution.

Spectroscopic targets are prepared on 35 µg·cm$^{-2}$ polyimide foils whether or not covered with a 50 µg·cm$^{-2}$ gold layer. We produce them by in-situ polymerization. Glass plates, pre-treated in a plasma to increase the hydrophilicity, are covered with a polycondensate solution in a spin coater, see Figure 3. The polymerization is performed at 350˚C in a dust-free oven. Finally, we cut the foils on the glass plate and transfer them on a frame via a water surface in a laminar flow cabinet, see Figure 4. The polyimide foil can be coated afterwards with a 35 µg·cm$^{-2}$ Au layer by physical vapour deposition to become electrically conductive.

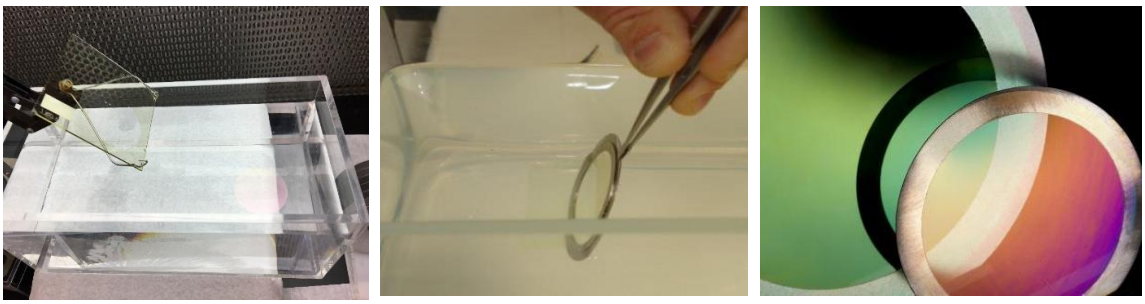

Figure 4: (Left) Releasing the polyimide foil from the glass plate onto the water surface; (Middle) Transferring the polyimide foil onto the ring; (Right) Polyimide foil on ring.

## Target characterization

Beside the high quality of targets, it is mandatory to characterize accurately the number of atoms and the number of atoms per unit area of the isotope of interest, the homogeneity and the presence of impurities influencing the experiments.

Thin actinide layers are characterized for their total alpha activity by low-geometry alpha-particle counting at a defined solid angle. We have two different set-ups: one alpha-particle counter with a variable (50-200 mm) and one with a fixed (1637 mm) target-to-detector distance, see Figure 5.

The solid angle, subtended by the target and the diaphragm in front of the detector, is determined by the distance of the target to the diaphragm, the inner diameter of the diaphragm and the diameter of the deposited layer. The latter is not measured directly on the target; instead we measure the inner diameter of the mask on top of the substrate during the physical vapour deposition or molecular plating. For the alpha counter with variable length, we establish the distance from the target to the diaphragm in front of the detector with calibrated gauge blocks. From the measured total alpha activity, the isotopic composition and the deposited area, the mass and areal density of the isotope of interest is calculated. To measure the activity distribution of the deposit we scan the target in the alpha-particle counter or with the gamma detector, see Figure 5.

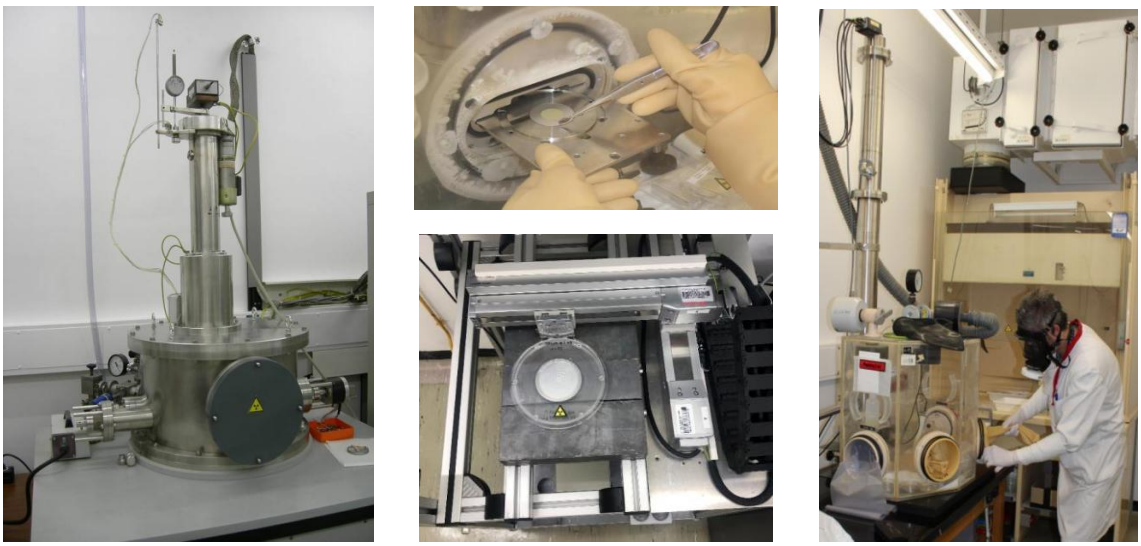

Figure 5: (Left) Alpha-particle counter with variable (50-200 mm) target-to-detector distance and axial and rotational movement for scanning; (Middle up) Mounting a target in the alpha chamber; (Middle down) Scanning of a target on top of a collimated Ge detector with an in-house made X-Y scanning system. (Right) Alpha-particle counter with a fixed (1637 mm) target-to-detector distance. The entrance of the alpha chamber is enclosed in a glove box.

Thin non-radioactive layers are characterized for their total mass by accurate weighing with a microbalance applying the substitution method, see Figure 6. We weigh the substrate before and after the deposition. The diameter of the deposited layer is not measured directly on the target; instead we measure the inner diameter of the mask on top of the substrate during the physical vapour deposition.

Metal targets like discs and foils are characterized for their mass and dimensions. The mass is determined by accurate weighing with a microbalance applying the substitution method. The diameter of the targets is measured accurately using a non-contact vision measuring microscope based on leading-edge optical technologies with a readability of 0.5 µm. The contour of the target is scanned several times at both sides. In case of a powder pellet the inside diameter of the press tool is taken. The thickness measurements are done with a calliper, in case of powder pellets, or a thickness gauge for the other targets. Prior to each set of measurements, we calibrate the instrument with reference gauge blocks.



Figure 6: (Left) Measuring the areal density of the polyimide foil on the glass plate with the visible light spectrophotometer in the light reflection mode and (Middle) of the foil transferred on the frame in the light transmission mode; Accurate weighing of a deposited layer by weighing.

The areal density of the polyimide foils is measured with a visible light spectrophotometer. We measure the amount of light that is refracted and/or reflected from the top and the bottom of the polyimide foil as function of the wavelength. The interference pattern is used to calculate the foil thickness. The light reflection mode is applied for foils on the glass plate and then the light transmission for the foils transferred on the frame, see Figure 6.

If you would like to learn more about our target laboratory activities and projects, feel free to get in touch with us: goedele.sibbens@ec.europa.eu

# News form the INTDS Board

INTDS website:

- Kristian Myhre from Oak Ridge National Laboratory accepted the offer of an assistant webmaster supporting Anna Stolarz in the task of administering and updating the INTDS web appearance.
- He presented his ideas on involving students and to also take advantage of social media platforms like LinkedIn for advertising INTDS.
- Posts on all INTDS media should have a corporate design to provide for a recognition value.
- Anna and Kristian will discuss the ideas and will present the plans in the Virtual Board Meeting in 2026.

Conference guidelines:

- Christelle and Matt work on an update of the conference guidelines of the INTDS and will present the status as soon as possible to the board.
- End of 2024 the INTDS finally was officially recognized as a 509(a)(2) public charity in the state of Tennessee, USA. Thus, the society has a tax-exempt status again, thanks to the indefatigable work of Matt.
- The board decided to move the INTDS bank account to an internationally recognized bank.

INTDS list:

- The INTDS list is currently hosted at the Florida State University and administrated by our honored member Powell Barber. Since Powell plans his retirement, the board decided to move the list in one or another form to the INDS website. Anna and Kristian think about the best way to implement.
- This is a good time to thank Powell for his longstanding dedication for the society!

Miscellaneous:

- The board consolidated the list and contact information of the emeriti.
- The reviewing process of the papers for the publication of the proceedings of INTDS 2024 are almost done!

# Orbituary

The INTDS society sadly lost a precious target maker:

Source: G. Otto, GSI/FAIR

## Vera Yakusheva

07.07.1961 – 04.03.2025

Vera Yakusheva joined the GSI target laboratory on 1 July 2010.

She has contributed and passed on her expertise in inorganic chemistry in the target laboratory. Countless experiments at GSI, in FAIR Phase 0 and from GSI at neighbouring accelerators have been made possible with targets produced by her. A great passion of hers was literature research and the incorporation of the knowledge thus gained into successful target production. Vera Yakusheva was a particular expert in adapting and transferring large-scale inorganic transformations to laboratory scale, especially for small quantities of highly enriched isotopes.

# Announcement

As part of the international society of nuclear targets, we are very happy and proud to announce that Sir Martyn Poliakoff, a famous chemist and very active youtuber, visited the GSI Target laboratory. His visit is documented in a YouTube video (https://www.youtube.com/watch?v=l85eip4zeew).


Sir Martyn Poliakoff in conversation with Dr Bettina Lommel in the Target laboratory.

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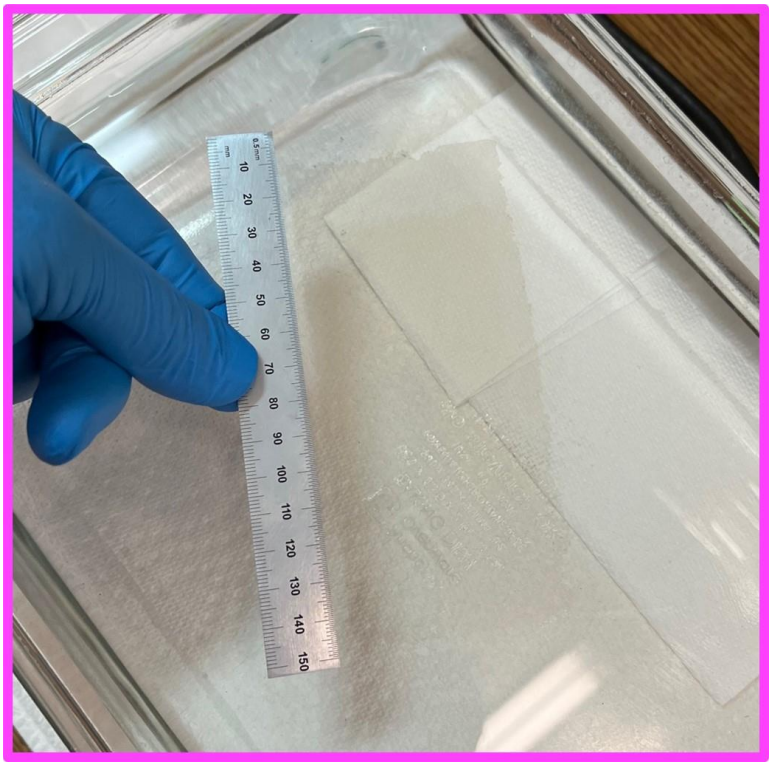

Photo: 0.1µg/cm$^2$ Arc evaporated carbon foil, 70mm x 140mm floating successfully and waiting for pick up.
Photo has been enhanced so the foil is more visible.

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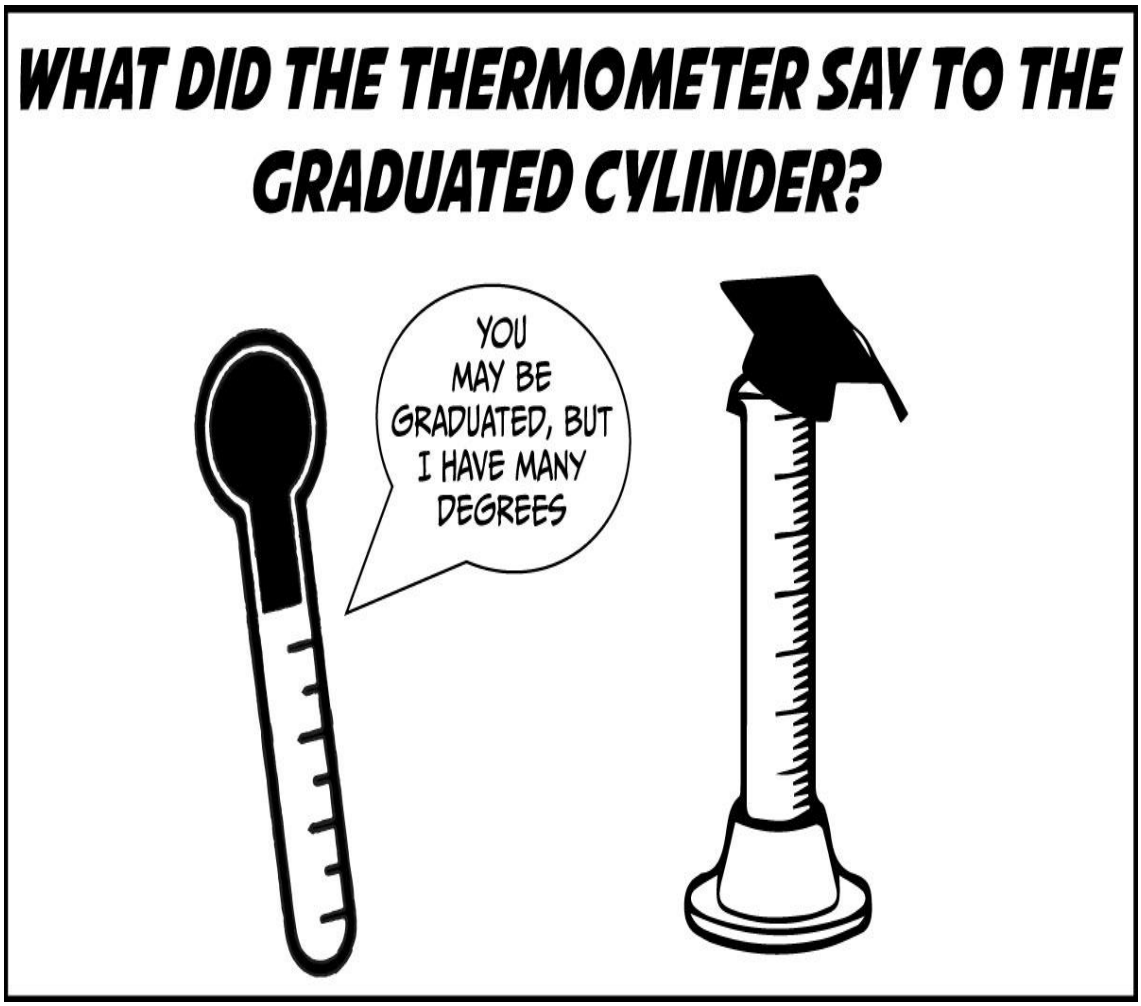


For further information on the INTDS, please refer to our website: www.intds.org.