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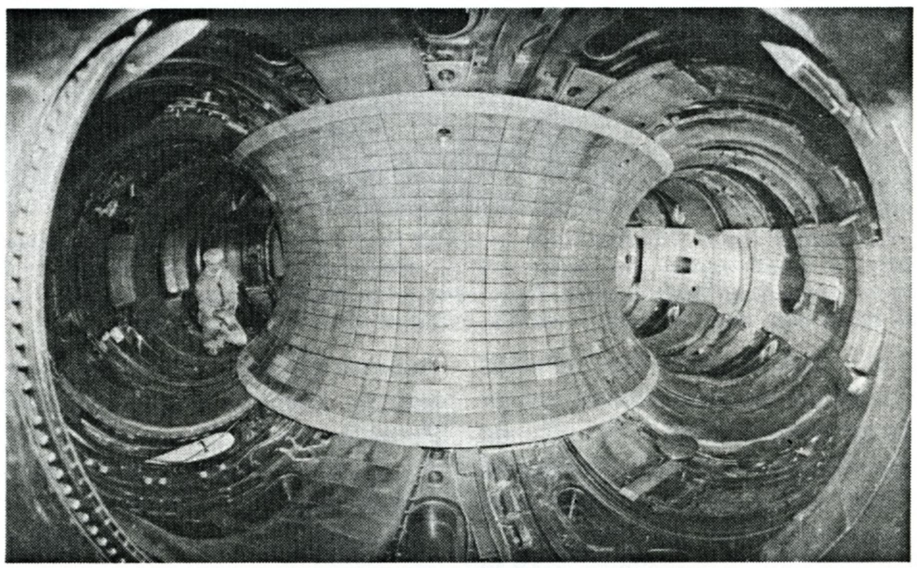
TFTR Prepares for D-T Experiments

Year-Long Activities in Homestretch

During a very busy seven-month outage (from November 1992 through May 1993), extensive preparations have been made for deuterium-tritium (D-T) operations. The D-T operations are scheduled to begin this summer, assuming successful contractor and Department of Energy (DOE) Operational Readiness Reviews (ORRs) which are in progress.



This dramatic view of the inside of the TFTR was taken with a fisheye lens. When deuterium-tritium operations begin and the inside of the Hot Cell becomes inaccessible, photos such as this will no longer be possible.

Tritium Division

Last fall, to increase the effort on TFTR D-T preparations, the Tritium Division was formed, headed by Jim Anderson. According to TFTR Project Head Richard Hawryluk, Anderson was chosen because of his extensive experience working with tritium at Los Alamos National Laboratory (LANL) where he was Head of the Tritium Systems Test Assembly (TSTA). There, 150 grams of tritium are on site (compared to a total of five grams to be used in TFTR).

Anderson is also familiar with the TFTR Project, having been involved in several tritium handling training sessions of TFTR staff over the years. Because of his familiarity with the project and his extensive tritium experience, he was also appointed to the TFTR Advisory Committee in fall of 1991 and was assigned to PPPL from LANL in November, 1992.

The Tritium Systems Division includes the Tritium Engineering Branch, headed by Bob Sissingh; Tritium Operations, headed by Charlie Gentile; and the Tritium Auxiliaries Branch, headed by Paul LaMarche. Planning and Control is headed by Sally Connell.

Successful Tritium Systems Tests

Since the important milestone that marked the arrival of tritium on site April 29, all relevant systems involved in the tritium systems have been checked for leaks.

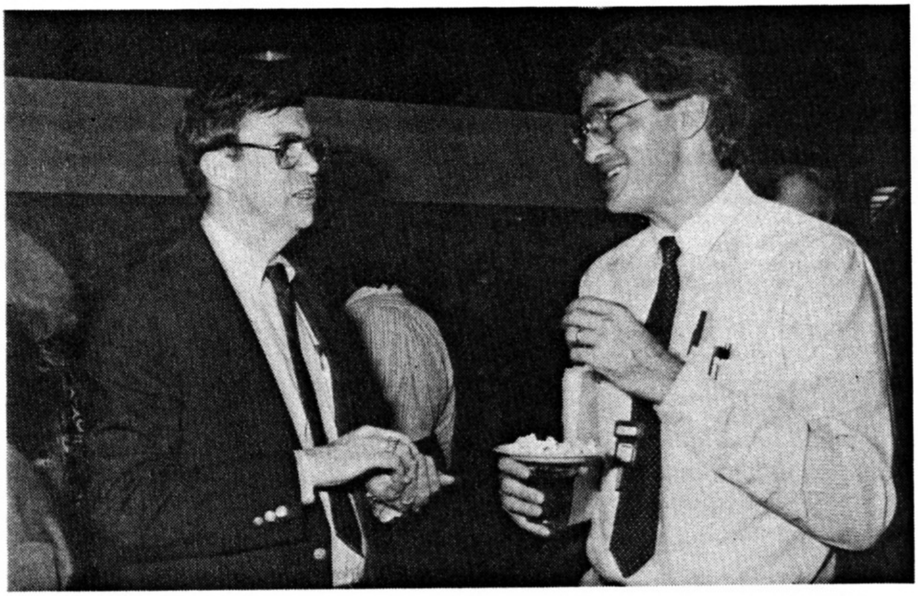
According to Bob Sissingh, Tritium Engineering Branch Head, "Throughout the tritium systems, we have detected only two tiny leaks (of components within the glove box) and these were easily corrected. Considering the fact that our equipment detects tritium with 1000 times more sensitivity that it does helium, this is a truly remarkable record."

Tritium Systems Technicians Lloyd Ciebiera and Denis Shaltis use a very sensitive tritium monitor to check for leaks. From the uranium bed, the tritium is pressurized, and all lines, compartments, and equipment of the various systems are tested. Also, tritium is injected into the glove boxes, and all window seals, gloves, and penetrations are checked for leaks.

Tritium systems checked were: the Storage and Delivery System, the Receiving System, the Analytical System, the Storage and Delivery Cleanup System, the Torus Cleanup System, the Gas Holding Tank, and all interconnecting lines.

Major Projects during Outage

Tasks competed since last November are too numerous to include here. However, some of the major additions are described, including:



TFTR Project Head Rich Hawryluk (left) and Paul Alling, TFTR Shift Supervisor, enjoy a laugh during the party held to celebrate the success of the April Operational Readiness Review. Before the party, Hawryluk gave a talk thanking all those who have worked so hard in preparation for D-T Operations.

a new neutral-beam gas injection system; an alternate cooling system for the toroildal field (TF) coils and the invention of a remotely controlled wrench to tighten the coil case bolts and the actual bolt tightening.

Others are: a new North Wall to provide additional shielding; a Decontamination (Decon) Facility in the Test Cell; the filling of room penetrations for fire, radiation, and tritium protection; and the set of video cameras in the Test Cell for remote viewing. All of these tasks were completed by the D-T Engineering Division headed by Erik Perry in close collaboration with the Mechanical Engineering Division headed by Dan Kungl.

In addition, three alpha confinement diagnostics have been added, tested, and will soon have radiation shielding installed around them.

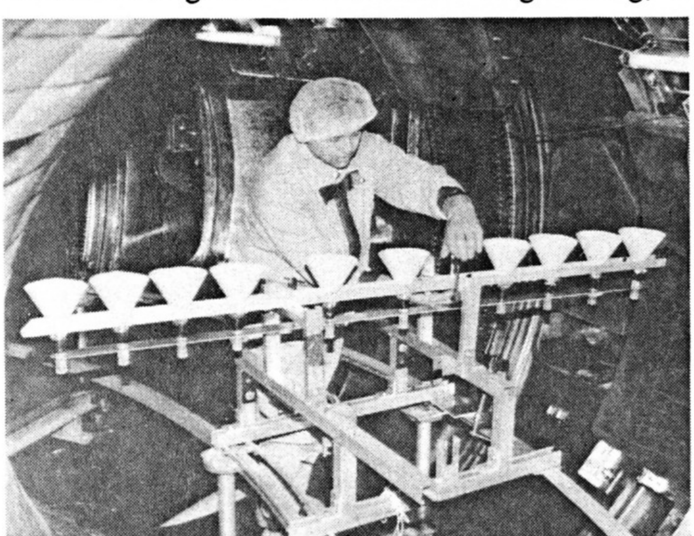
TF Coil Problems Solved

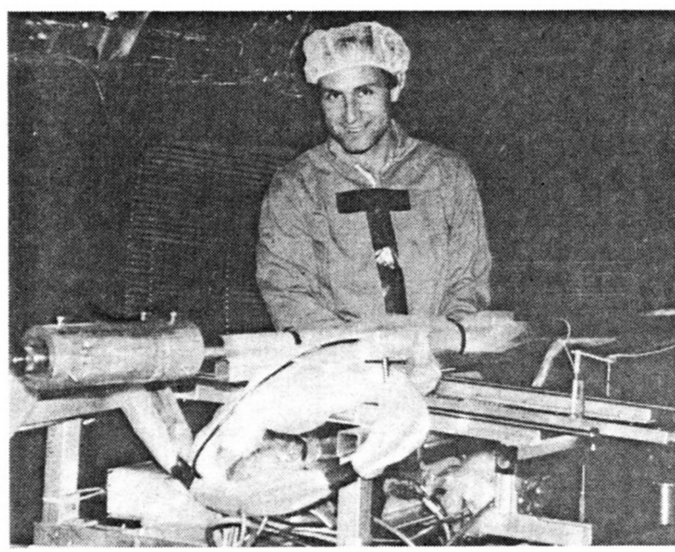
According to Harry Bush, Head of the Construction Branch of D-T Engineering, work done on the TFTR magnetic coils should solve two important problems that have plagued the coils—coil leaks and loose coil case bolts.

The 20 doughnut-shaped TF coils which surround the vacuum vessel provide a strong magnetic field to confine the plasma. Up to now, the coil coolant has been deionized water, running through the 1500 feet of copper conductor inside each coil.

However, miniscule leaks that allow water to escape into the insulation have been of great concern because they reduce the coils' resistance to ground. Although coil leak repairs have been successful, leaks have recurred and new leaks have appeared.

Therefore, according to Cognizant Engineer Russ Walton, deionized water has been replaced with perfluoroheptane (Fluorinert) as a coolant. Explains Walton, "Fluorinert was chosen for its compatibility with existing materials in the TF coil coolant paths, chemical and radiological stability, and environmental acceptability. Most important, because of its high dielectric strength, Fluorinert should prevent the degradation of coil resistance to ground even if it saturates the coil insulation."





Inside the TFTR vacuum vessel, Tom Holoman works on the Neutron Source (left photo), while David Cylinder adjusts the Neutron Generator (right photo).

Adds Walton, "To prepare for operation with Fluorinert, we made extensive modifications to the TF cooling system. In addition, we have now fixed all the leaks and installed the Fluorinert. Should small leaks develop during D-T operations, they shouldn't be a major concern."

Remote Wrench Invented to Tighten Coil Case Bolts

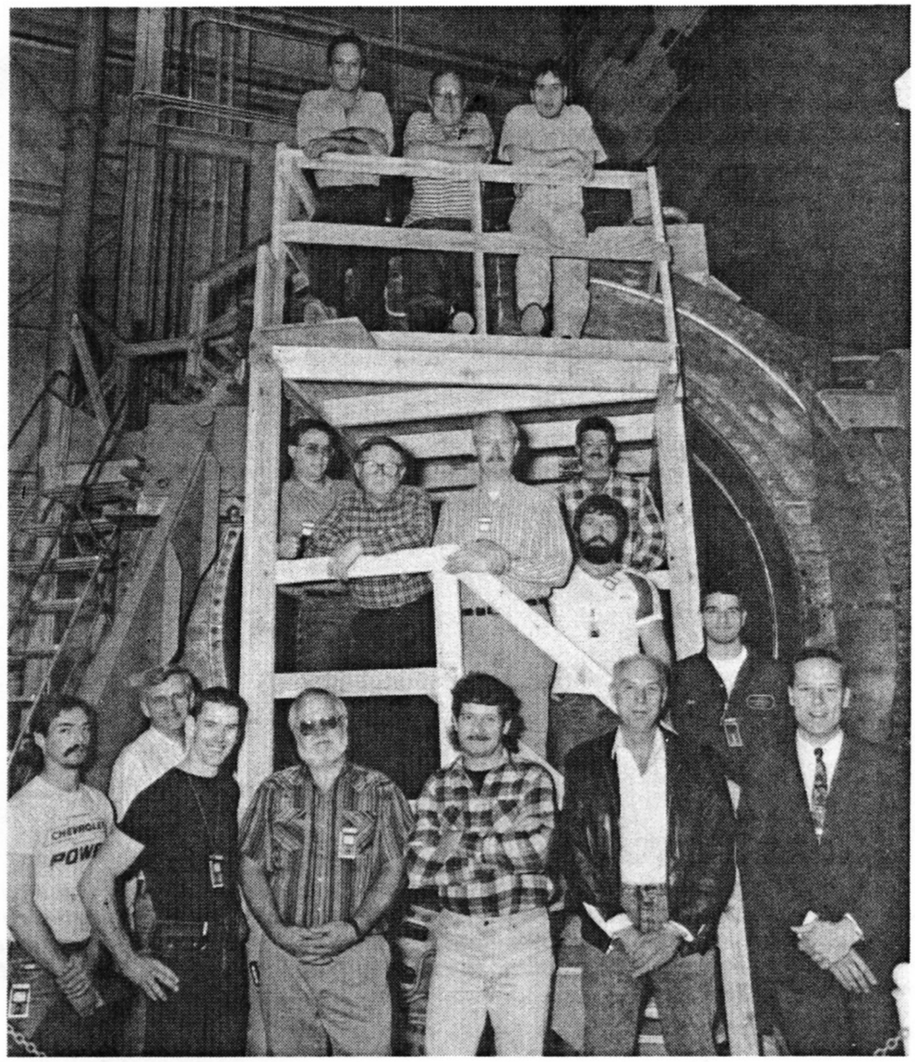
When the TF coils were manufactured, they were enclosed in cases that were assembled using bolts as fasteners. However, over the years the bolts in certain areas—including many in inaccessible places—have loosened. Loose bolts place restrictions on coil operating conditions.

Since 1988, several attempts have been made to find a solution to this problem. Finally, Tom Burgess, an engineer from Oak Ridge National Laboratory who specializes in remote handling technology development, led an effort to resolve the loose bolt problem.

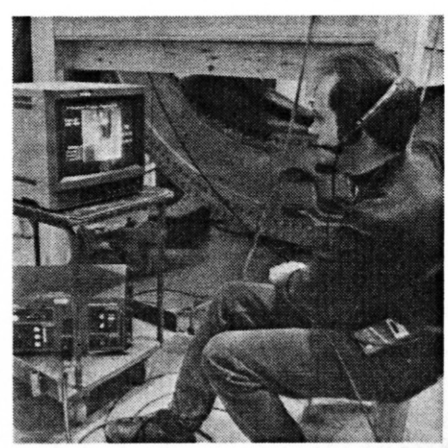
Special remote tooling consisting of a cable-controlled wrench head (see photo page 4) integrated with remote viewing equipment resulted. This unique tooling was successfully able to reach into the half-inch wide space deep between the coils to tighten the bolts located in the nose regions of the coils. Three versions of the wrench were required because of different bolt configurations.

After successful testing on the TF coil in the mock-up area, the wrench assemblies were first used to tighten those 1000 bolts which were of most concern. With two four-man teams operating the equipment, most of the loose bolts have now been successfully tightened to 100 foot-pounds or more.

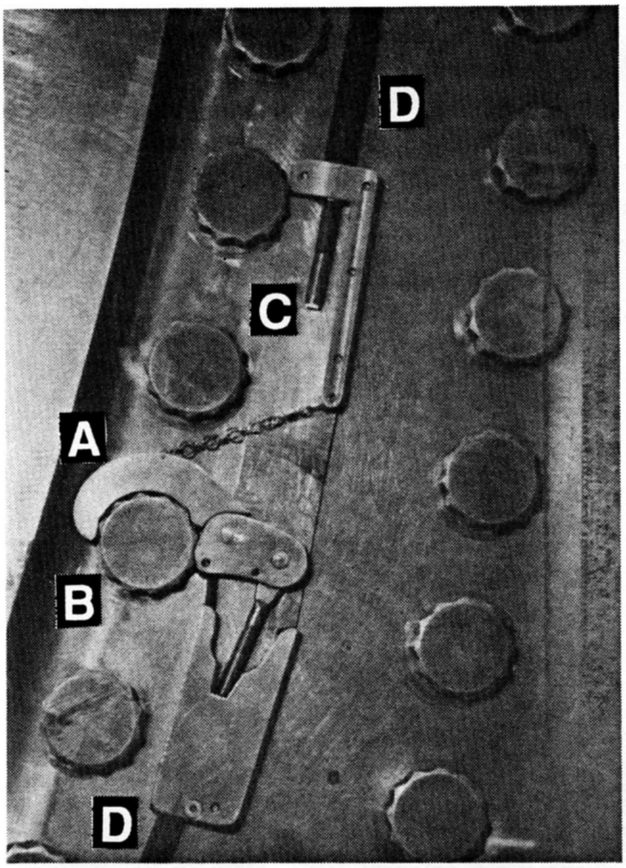
Said Burgess, "We're very pleased that the tooling has been so successful. Because the tightened



The crew who participated in the development and use of the remote tooling pose on the scaffolding erected around the TF coils in the mock-up area. Left to right are, first row, Tommy Paller, Tom Meighan, Jim Walton, Ed Hill, Ron Teeter, Bruce Paul, and Tom Burgess. On the middle platform are Mark Karlik, Frank Polom, Jack Mount, and George Hutton, with Joe LaRochelle Sr. and Rick Freese on the steps. At top are Frank Terlitz, Dick Yager, and Joe LaRochelle, Jr.



During mock-up testing, Jim Walton (left photo) operates the T-handle of the wrench cable to remotely tighten a bolt, using the monitor to his left to position the wrench head. At the same time, Frank Terlitz monitors and controls the video image so that Walton can view the operation.



Shown is the wrench assembly for the 7/8-inch inner row bolts. Here, the ratcheting wrench jaw (A) is gripping the bolt (B). Above it the remote viewing probe (C) illuminates the area for remote viewing. The dark lines(D) are the controlling cables.

To Bob Kneeshaw's left are some cables which go from TFTR to the Test Cell basement through a nine-inch hole (penetration). Here, Kneeshaw stuffs ceramic fiber (which looks like a rope) into the hole in preparation for filling it with RTV to seal it in case of fire, smoke, or tritium.

bolts improve the mechanical integrity of the coils, an increase in the coil electrical current might be possible, which may result in better fusion performance during the D-T phase."

Bumper Limiter

An unexpected problem was discovered when the TFTR was opened last November. Explained Bush, "We found that more damage had occurred to the bumper limiter tiles than was predicted, and 238 of them had to be replaced. Our In-Vessel Manager, Doug Loesser, led the effort on an accelerated schedule to produce these replacement tiles." Added Bush, "The job was made more challenging by the fact that appropriate carbon-carbon composite to manufacture the tiles is difficult to get."

Members of the in-vessel crew, in contamination suits, pose inside the TFTR Vacuum Vessel. Left to right are Doug Loesser, Bob Horner, Jim Benchoff, and Mike DiMattia.

Said Loesser, "We redesigned and replaced the tiles—in many cases with tiles which have greater thermal and mechanical strength."

In addition, according to Loesser, the Mirnov Coils, which measure magnetic fields within the vessel, sustained unexpected heat damage. To protect them during D-T operations, shield tiles similar to the bumper limiter tiles were designed, manufactured, and installed.

Penetration Filling

According to Task Manager Mike Lazar, "To prepare for tritium, 858 floor and wall openings, and electrical and cable conduits had to be sealed against fire, smoke, and tritium. To seal these openings (called penetrations) a fire-stopping material called RTV (Room Temperature Vulcanization) was used." Explained Lazar, "RTV is a sticky liquid that dries like rubber. The most challenging part of this effort was coordinating the penetration filling with the installation work going on in and around the penetrations. It was sometimes a scheduling nightmare."

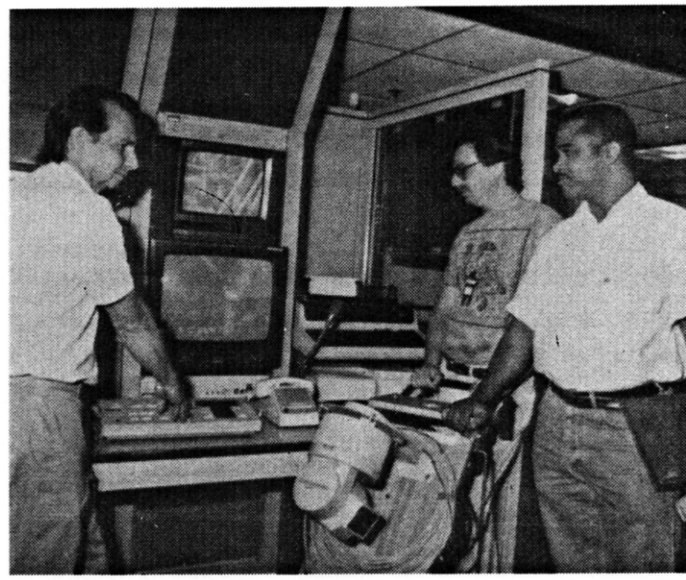
New North Wall

Don't do a double take when you see the north wall of the TFTR Test Cell—there are now *two* north walls! According to Harry Bush, the second wall, made of concrete one foot thick, was installed as additional neutron shielding to protect the mock-up area during deuterium-tritium operations and to reduce the level of radiation at the site boundary. The new shield wall is set six feet out from the original north wall in order to accommodate existing components installed on the original wall. A support beam attaching the two walls ensures seismic support in case of an earthquake.

Test Cell Television

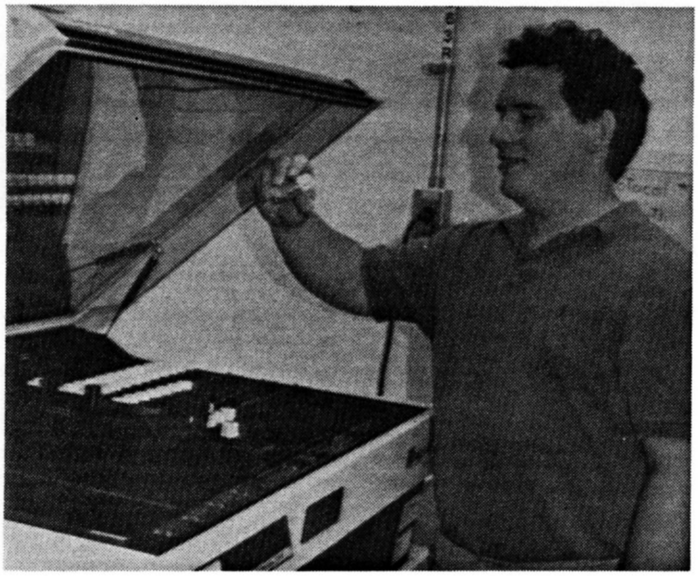
For purposes of remote viewing during D-T operations, ten new color cameras have been installed in the Test Cell. These cameras replace a much more limited camera system and are designed to diagnose problems during the days and weeks of no access that can occur after a sequence of D-T shots. The cameras will be helpful in monitoring the neutral beams for nitrogen or helium blowoffs, as well as for detecting leaks, frost, and arcing.

Said Cognizant Engineer George Kolinchak, "We've put in eight cameras on the walls—one at each direction and one at each side wall. In addition, for increased viewing flexibility, we have two cameras mounted on movable carts. Two monitors for the cameras, located in the TFTR control room, provide the capacity to view the area in question from two positions at once. Viewing will be quite flexible, since the cameras can pan, tilt, and zoom for a closer look. The cameras and monitors exhibit excellent clarity and resolution." Adds Kolinchak, "Because the system has demonstrated such high quality and performance, five additional cameras have been installed in the tritium area—two in the clean-up area, one in the waste handling area, one in the vault, and one in the control room."

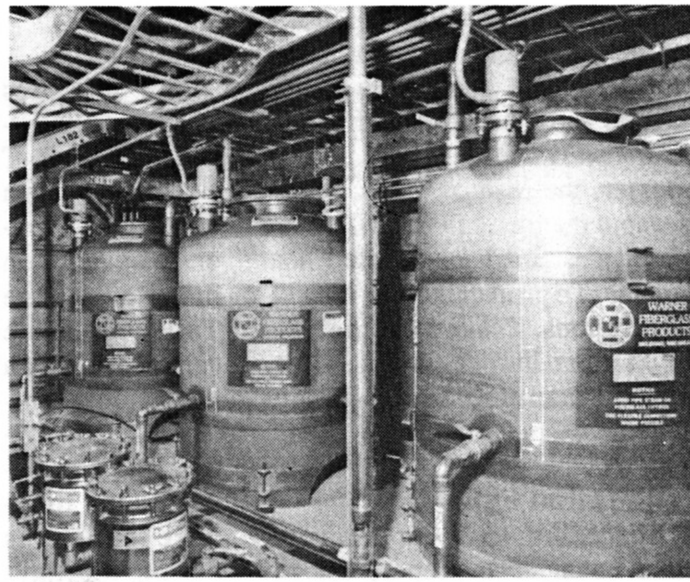


In the TFTR control room, George Kolinchak (left) works the remote pan, tilt, and zoom controls for the ten Test Cell video cameras while Matt Reiter and Anthony Wesson look on. Reiter is pushing the cart which holds one of the two mobile cameras.

The complete camera installation team, posing with the mobile camera, included, left to right, Matt Reiter, Glenn Feller, Tony Wesson, George Kolinchak, Richard Such (behind Frank Anderson), and Louis Raics.



Steve Williams prepares samples for the Health Physics Liquid Scintillation Analyzer.



The new Decontamination Facility's waste water collection system includes three large Liquid Effluent Collection Tanks.

Decon Facility

Whether you need to wash anti–contamination suits, monitor equipment, or do machining of activated/contaminated components, it's one-stop service in the new Decontamination (Decon) Facility that has been set up in the TFTR Hot Cell. Said Jim Chrzanowski, Cognizant Engineer for Decon Facility construction, "It's convenient to have the laundry room for tritium-contaminated clothing and the personnel decontamination shower and changing area as well as the other decontamination activities all in one place."

The new TFTR Decon Facility houses a new washing machine demonstrated by Jim Chrzanowski (left) and Jerry Gething.

Also within the Decon Facility are a radiation waste materials packing area with a compactor, a "hot" machine shop area for working on contaminated/activated materials, and a general health physics laboratory that includes devices to measure tritium levels and to monitor equipment and clothing.

In addition, two ultrasonic cleaning areas have been installed. One of these is within an explosive-proof room, which would be used if flammable liquids such as ethanol are required during ultrasonic cleaning of components. This area also includes a new oven for baking out ultrasonically cleaned components.

The Decon Facility has numerous safety features. Says Chrzanowski, "The Facility, which is within the tritium boundary, has a pre-action sprinkler system for fire protection, uninterrupted power system (UPS), and a ventilation system which provides a negative pressure atmosphere. The exhaust is routed to the TFTR stack. Because of the negative pressure, air tends to be sucked into the area rather than blown out."

For the protection of individuals working in the area, a series of alarms and safeguards have been included. These include fire/smoke sensors, tritium monitors, low flow ventilation alarms, and warning systems associated with the water

Roy Clugston separates contaminated waste for compacting.

level in the waste collection system. Finally, the Decon Facility has its own waste water collection system, which allows the collected waters to be filtered and tested prior to releasing to the TFTR Liquid Effluent Collection Tanks (LECT).

Heating Systems

According to Heating Systems Division Head Al Von Halle, "Training at various levels has been a very important activity during the past months—some personnel have been trained, others have been qualified, and still others certified. At the same time, all our procedures have been rewritten to include the considerations necessary when using tritium. As a result, we are confident with our preparations to run the heating systems during D-T operations."

"Intensive maintenance work has also been completed on the heating systems with the knowledge that during D-T operations we will be running TFTR for 18 months without an opening," adds Von Halle. "In addition, the gas injection system has been replaced to accommodate the use of tritium."

Neutral-Beam D-T Gas Delivery System

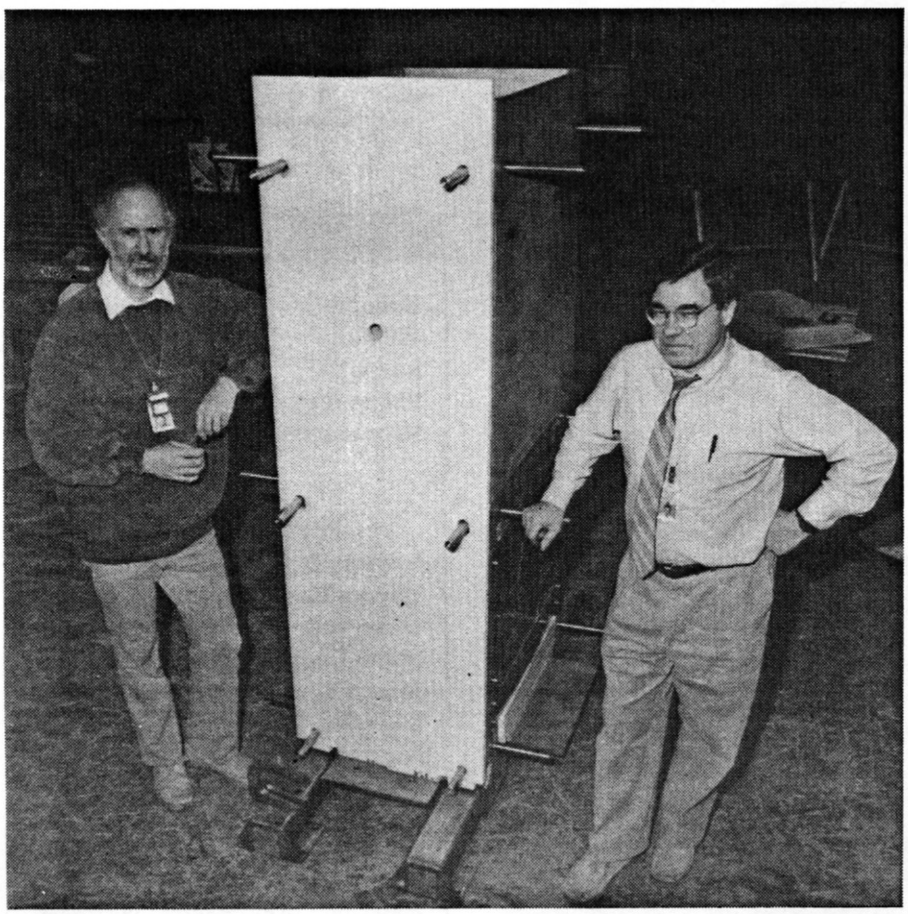
The Neutral-Beam Injection System currently provides up to 33 megawatts (MW) of deuterium beam heating, and the System will provide up to 36 MW of D-T neutral particle beam heating to TFTR plasmas when D-T operations being.

During D-T operations, six of the twelve Neutral-Beam (NB) Long-Pulse Ion Sources (LPIS) will be operated using tritium to obtain the proper ratio of deuterium and tritium within the plasma, according to Ken Wright, NB Mechanical Engineer. However, for maximum operational flexibility, all 12 of the LPISs have been outfitted with a new D-T gas injection system.

This new gas delivery system is designed to deliver either tritium or deuterium gas with uniform throughput (constant flowrate of actual particles) to fuel the LPISs, according to NB Controls Engineer Mark Oldaker, who, along with J.E. Lawson, was responsible for developing the electronic and PLC controls for the injection system.

Explains Oldaker, "The injection of gas is under the control of a servo-loop that monitors the local gas holding plenum and ensures a constant throughput by forcing the plenum pressure to drop in a linear manner."

The system is designed with numerous safety features. For example, it actually consists of two separate subsystems for delivering deuterium and tritium, according to Wright. He notes, "The subsystems are modular so that they can be more easily removed and replaced. This will minimize personnel exposure to radiation during maintenance. In addition, to ensure its confinement, the primary tritium gas supply is enclosed in a coaxial confinement tube, which will be monitored to detect any possible leakage."



Sid Medley (left) and Rudy Prechter with the radiation shielding for the Alpha Charge-Exchange Diagnostic (see photo, page 8.)

Alpha Diagnostics

During D-T operations, a new, and very important, aspect of fusion physics—alpha particles—can be studied for the first time in TFTR, according to Principal Research Physicist Sid Medley.

In the course of a D-T plasma shot, helium nuclei—termed alpha particles—are produced. The plasma tends to lose energy for various reasons, and alpha particles are essential to replenish that energy. Therefore, understanding the behavior of alpha particles and finding methods to keep them confined is pivotal to maintaining ignition in the plasma of a future reactor.

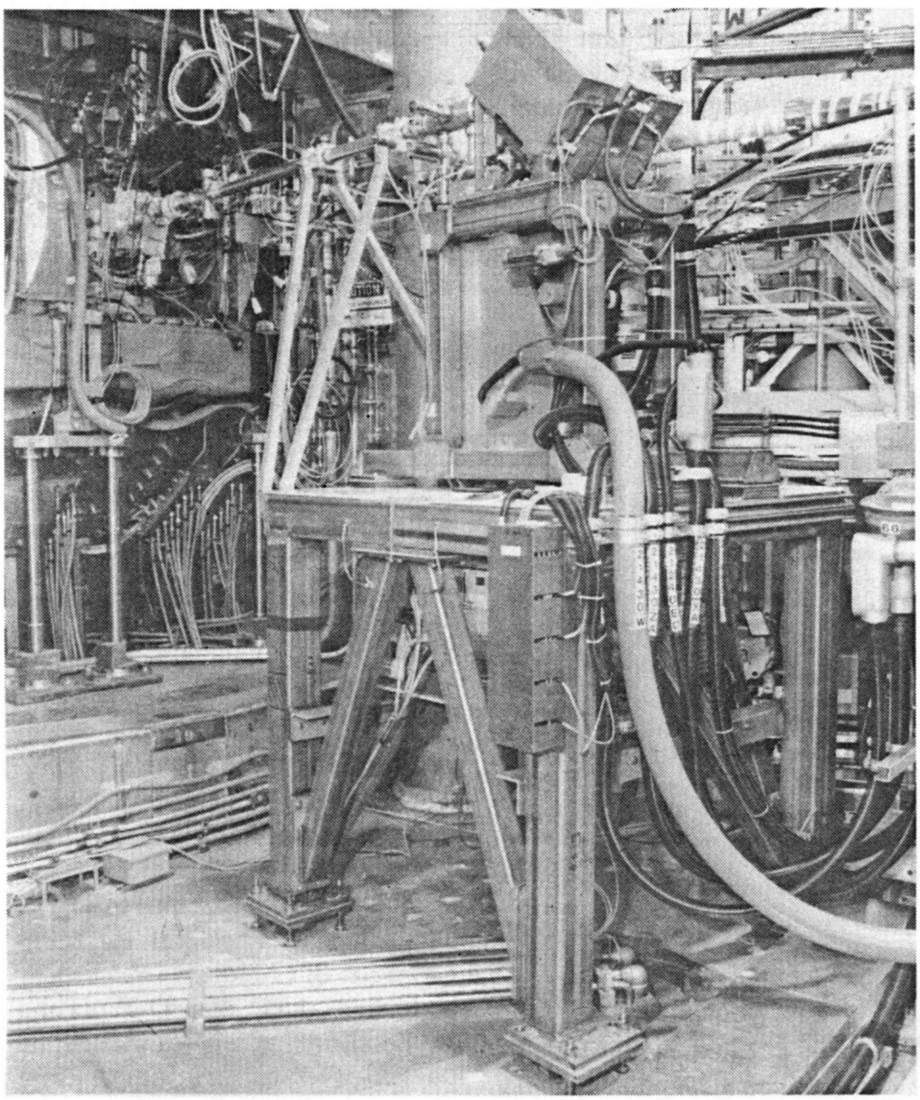
Says Medley, "Right now, a major question is whether the alpha particles will be lost from the plasma before their energy can be absorbed to heat the plasma."

As Physicist Bruce Stratton notes, "Only TFTR and JET (Joint European Torus) will be able to provide experimental information on the physics of D-T alphas before the operation of ITER. Therefore, the alpha physics to be studied during the TFTR D-T run is extremely valuable to the worldwide fusion program."

Adds Stratton, "To achieve this goal, several dedicated confined-alpha diagnostics* are being implemented for the D-T run: Alpha-CHERS, the Alpha Charge Exchange diagnostic, and Collective Thomson Scattering (gyrotron scattering)." The first two of these have been installed and tested during deuterium-deuterium (D-D) discharges, while the third is just now being added.

To protect diagnostics from high levels of neutrons—which could cause the detectors to give a false reading—radiation shields are being installed around them, for example, on the Alpha Charge Exchange. Shielding consists of four inches of lead covered by eight inches of polyethylene with a cement board fire retardant covering. Because the shielding makes it difficult to further adjust the diagnostics, it will be installed when D-D testing is complete.❖

**An article on the alpha diagnostics and the measurements being obtained on them is planned for the fall, after D-T operations commence.*



The Alpha Charge Exchange Diagnostic—sitting on a large four-legged stand.

All photos in this issue were taken by Dietmar Krause.

TFTR

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