TRIGA Facility Improvements at Texas A&M: Equipment and Administration

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Abstract: The concepts of Aging Management are not only applicable to physical components, but also to administrative structures. The Texas A&M Experiment Station (TEES) Nuclear Science Center (NSC) has completed major infrastructure upgrades in recent years. These significant infrastructure investments have put the NSC in position to have the equipment needed to operate through at least the end of its current license period. However, the best equipment available is useless if it cannot be operated well. A need was identified to improve the facility's Administration Plan to support the operation of new infrastructure. This improvement effort seeks to transition the facility from depending on individual personalities in determining the administration of the facility to depending on an instituted set of standards. Ideas for the plan were collected by listening to best practices from personnel in nuclear facilities worldwide. These facilities included power plants, fuel manufacturing facilities, mining operations, research reactors, research labs, and regulators. Site specific needs were considered and an outline created. The Administration Plan grew out of these efforts. The Administration Plan is governed by the overall Safety Plan to administer the facility in a way that protects the safety of the public. It describes the relationship between employees, the facility, and their respective goals. The plan assumes that employees are interested in personal development and that the facility views employees as its most important resource. It realizes that employee development supports safety goals through increased personal capability. While the components of the plan work together in a web, it is possible to develop and introduce the components individually. The NSC's progress towards implementing an Administration Plan is not complete. Aspects are being introduced in an incremental way as resources allow development. Major components have been identified and can be developed and introduced individually. Future work will focus on continuing this process.

Infrastructure Upgrades

The Texas A&M Engineering Experiment Station (TEES) Nuclear Science Center (NSC) has completed major infrastructure upgrades in recent years. These upgrades were made possible, for the most part, through funding from the U.S. Department of Energy (DOE) and TEES. The upgrades have focused on aging support equipment and include: the confinement building ventilation system, the facility fire detection system, the facility security system, the facility (transient rod) compressed air supply, the cooling primary loop pump, the cooling secondary loop pump, the cooling tower, the heat exchanger, the facility air monitors, and the pool water purification system, as well as an in-progress project to replace the facility's electrical distribution system. In addition to these support equipment upgrades, we have also restored the Lower Research Level as an area capable of supporting research with five beam ports ready for line development and a newly-installed a telemanipulator hot cell.

Ventilation

The confinement building ventilation system was installed as part of the original construction in 1961. Figure 1 shows the old control panel prior to its removal. The old ventilation system was comprised of a central exhaust, four air handling units, their controls, and their associated ductwork. Airflow and isolation was controlled by pneumatically operated louvers, and the system could either automatically maintain defined area pressure set points or be manually operated. Only one control panel was available in the Emergency Support Center. This meant that operations personnel would have to exit the confinement building to make adjustments to the system or perform periodic operating tests. Over time, the operability of this control system degraded and repair became challenging.

In 2006, the confinement ventilation system was replaced, with the exception of some ductwork. A new central exhaust with installed spare was installed, the four air handling units were consolidated into three new units, and a new control system was installed. Airflow and isolation is controlled by electric servo-operated louvers that isolate the system on loss of power.

The new system allows multiple control panels to be configured. Currently the system can be controlled either from the Emergency Support Center or the Reactor Control Room. This has allowed greater awareness of building pressure, greater control of building pressure, and improved ease in conducting periodic tests.

Fire Detection

Prior to 2010, the NSC's fire detection system was seven smoke detectors designed for home use, only five of which were in the confinement building. An alarm signal from any of these detectors would light a single bulb at the University Communications Center. A need for an adequate fire detection system was identified. An upgraded system was installed with dozens detection points, on-site warning broadcasts and alarms, and detailed off-site notification for not only the confinement building, but also all of the buildings on site. The system also features the ability to make site-wide announcements over the fire detection alarm system. This has greatly improved our ability to make site-wide announcements during emergency situations.

Reactor Cooling

While the original cooling system was rated for 5 MW_{th}, by 2010 extended operations during summer months were often limited by high pool temperatures. The cooling system was composed of a single speed primary loop pump, a U-tube heat exchanger, a single speed secondary loop pump, all installed in 1968, and a wooden cooling tower built in the 1980s.

For the first 15 or so years of the cooling tower's life, and presumably prior to then in the tower it replaced, chemistry was not controlled in the secondary loop. Continuous exposure to high pH water degraded the wood of the cooling tower and scale buildup was a problem in metallic components (Figure 2).

In many places it was possible to simply push one's finger through the wooden structure of the cooling tower. Nails and other fasteners could no longer remain in place, and the fill, slats, and skin of the tower began to collapse. Scale buildup made isolation valves inoperable (for example, a valve handle broke off while trying to cycle it with a second person), and leaks became constant. Replacement was needed.

A steel SPX (Houston) cooling tower [1](Figure 4), variable speed pump for the primary loop[2], and pump for the secondary loop[3] were installed. The new cooling tower and pumps improved the cooling situation, but pool temperature remained a problem during the summer months.

Cooling system performance and knowledge of the previous lack of water chemistry control on the secondary side in past strongly suggested the secondary side of the heat exchanger was fouled. Additional evidence of this became apparent in the five years preceding its replacement when corrosion leaks formed on several places on the shell. In 2013, funds became available to replace the U-tube heat exchanger with a modern plate and frame heat exchanger[4]. The U-tube heat exchanger had to be cut apart for removal, and this process confirmed that the secondary side was indeed quite fouled (Figure 3). The plate and frame heat exchanger is very easy to clean and otherwise maintain, and cleaning is now a part of our routine maintenance cycle. The new system comprised of two new pumps, new cooling tower, new heat exchanger, and chemistry-controlled water in both loops has demonstrated a significant improvement over the previous system. During the most intense part of the summer, pool water temperature is readily maintained below 90°F during operations.

Facility Compressed Air (Transient Rod Air Supply)

During initial construction of the NSC, a used 1950s Ingersoll-Rand air compressor was installed to provide compressed air for the facility. This air compressor became the source of air for the transient rod after the conversion to a TRIGA reactor in 1968. By 2012, wear in the mechanically operated pressure control made it difficult to maintain a stable air pressure. Adjustments frequently required new parts to be ordered or machined, and could take hours or even days to be completed. The growing unreliability of the system was identified as a threat to reliable reactor operations. In 2012, a new Ingersoll-Rand air compressor was installed and has worked reliably.

Demineralizer

The demineralizer system was an original installation of the facility and was using resin that was installed in the late 1980s. Over the past ten years resin regeneration went from being a quarterly event, to being necessary every two weeks. The increase in hazardous chemical handling, chemical costs, and reduced performance of the system was undesirable. The equipment, and

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[1] Evaporative cooling tower with fan-driven induced draft; high heat load capacity (function of atmospheric conditions and inlet temperature); for 100% humidity on 100°F day and 1MW heat load, the outlet temperature is 79°F; system capacity can be as high as 5MW

[2] 45kW motor; 1780 rpm max (variable); max flow rate 1425 gpm; max head 109 ft

[3] 45kW motor; 1775 rpm (single speed); max flow rate 1950 gpm; max head 90 ft

[4] 164 plates-single pass; 4.6 MW capacity with primary inlet 1000 gpm at 114 °F and secondary inlet 1900 gpm at 80 °F; max pressure 195 psi

indeed the room itself, was corroded and scarred from 55 years of use. The old system was removed, the room resurfaced, and a new system installed (Figure 7). The new system incorporates a reverse osmosis filter to pre-filter city water during pool fills to extend resin life. The new system has only been in service five months, so it is not yet known how frequently resin regeneration will be necessary.

Lower Research Level

The lowest level of the confinement building is called the lower research level, or LRL. The LRL has access points for five beam ports and a thermal column as well as three hot labs. Over the past several decades, it had become a storage area for abandoned equipment rather than being a hub for research activity. The level was completely emptied, floor resurfaced, and walls painted. The area is now ready for development of new experiments and equipment (Figures 5 and 6).

Administration Plan

These significant infrastructure investments have put the NSC in position to have the equipment needed to operate through at least the end of its current license period. However, the best equipment available is useless if it cannot be operated well. Recent personnel turnover at the NSC highlighted a personality driven administration, with limited shared responsibility or oversight. A need was identified to develop a facility Administration Plan to help provide stable facility administration into the future. This effort seeks to transition the facility from depending on individual personalities in determining the administration of the facility to depending on an instituted set of standards.

Foundational Work

Ideas for the plan were collected by listing to best practices from personnel in nuclear facilities in 29 countries. These facilities included mining operations, uranium conversion, uranium enrichment, fuel manufacturing, research reactors, research laboratories, power plants, and regulators. Site specific needs were then considered and an outline of the Administration Plan was created. It describes the relationship between employees, the facility, and their respective goals.

The components that make up the Administration Plan function together (Figure 8).. It is possible to develop and implement most, if not all, of these components incrementally. This incremental development and implantation approach has allowed us to focus on each component and prevents being overwhelmed by attempting to complete too much at once.

Some action was required prior to beginning work on the individual components of the Administration Plan. Overall safety, including nuclear safety, was found to be degraded both by the U.S. NRC and a review by TRTR members. A healthy nuclear safety culture is necessary not only for an Administration Plan, but also if all activities at a reactor are to be guided by a commitment to protect the safety of the public.

Work began on a top level document, a facility Safety Plan, that includes all aspects of safety, e.g., nuclear, chemical, laboratory, industrial. The nuclear component was addressed first. Heavy guidance was taken from INPO 12-012, Traits of a Healthy Nuclear Safety Culture, and other tools used widely throughout industry such as job safety analyses, pre-job briefs, near-miss and incident reporting, root cause analyses, and facility posting of this information.

We also identified a need for stated facility goals, or a vision and mission[5], to guide the Administration Plan. There are many methods for developing facility goals, and we chose a method inspired by INPO 12-012 WE.2 Opinions are Valued:

> Individuals are encouraged to voice concerns, provide suggestions, and raise questions. Differing opinions are respected.

With this in mind, we distributed a survey to all employees of the NSC, including students, for input on what they thought the purpose of the organization should be and how we should get there. After the results were collected, we had a meeting with all interested parties to talk about them as a group. After the discussion with this group, NSC management finalized a vision statement and new mission statement for the organization.

> Vision: Our vision is to be the premiere center in safely supporting nuclear research and training.
>
> Mission: We provide high level research and training to all users through safe application of an on-site training reactor, various other unique research and engineering tools, and innovative, knowledgeable, and experienced personnel.

Administration Plan Development

After completing these foundational tasks, we had guidance on how the Administration Plan should develop. The Administration Plan assumes both that employees are interested in personal development and that the facility views employees as its most important resource. It realizes that employee development supports safety goals through increased personnel capability.

Employee development is one of the main focuses of the Administration Plan, and a hub that all of the components connect to. It is a valuable resource for both the facility and employees. Capable employees should feel proud about improving themselves, contributing to their progression along their career plan, bringing enhanced skills to the organization, and better understanding what is needed to support a healthy safety culture. Employee development can and should come both from internal and external opportunities.

One contributor to employee development is career planning. The facility and employees should work together to plan goals, advancement, and other career topics. There should be clearly defined advancement paths and requirements to advance along those paths. Individual career paths should be periodically reviewed and revised.

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[5] IAEA-TECDOC-1212, "Strategic planning for research reactors," International Atomic Energy Agency, April 2001.

One obstacle to career planning that we found was that well-defined positions did not exist. Well-defined positions with clear position descriptions and responsibilities are crucial to supporting development and to supporting good understanding of expectations both by employees and by the facility. A review of all position descriptions existing at the time and comparison to the actual responsibilities of employees was made. Based on that review, position descriptions were updated, and some employees were moved into different positions.
Key performance indicators (KPIs) can be a useful tool for measuring employee development and performance. KPIs are objective measures on key responsibilities or outcomes. They are being developed for all positions to measure performance, allow for quick and useful feedback, and to identify employees who excel or struggle in specific areas.

Performance reviews are the feedback management provide to employees about their development. Currently performance reviews are done annually, and have the potential to be quite subjective. In the future they will incorporate KPI data to provide objective feedback and occur frequently enough to actually be useful to employees.

As mentioned before, not all development needs to come from external opportunities. Through KPI data and performance reviews, skilled internal trainers can be identified to contribute to others' development. The expertise of these trainers should be shared as widely as possible and captured for future knowledge transfer.

We predict that a focus on these core components will allow all the members of the NSC to work together to maintain a healthy nuclear safety culture and to reach facility goals.

Summary

The TEES NSC has completed major infrastructure upgrades through funding from the DOE and TEES. The upgrades were focused on aging support equipment. With these infrastructure upgrades in place, the NSC is well poised to continue operating at least through the end of the current license period. A need for administrative upgrades was also identified to compliment the infrastructure upgrades. The administrative upgrades are in progress, and will ensure that the NSC not only has high quality equipment, but also high quality administration.

Figures

Figure 1: 1961 Ventilation Controls

Figure 2: Old Cooling Tower Pipe

Figure 3: Old Heat Exchanger Corrosion

Figures

Figure 4: New Cooling Tower

Figure 5: New Handling Cell

Figure 6: Lower Research Level Refurbished

Figures

Figure 7: New Demineralizer System

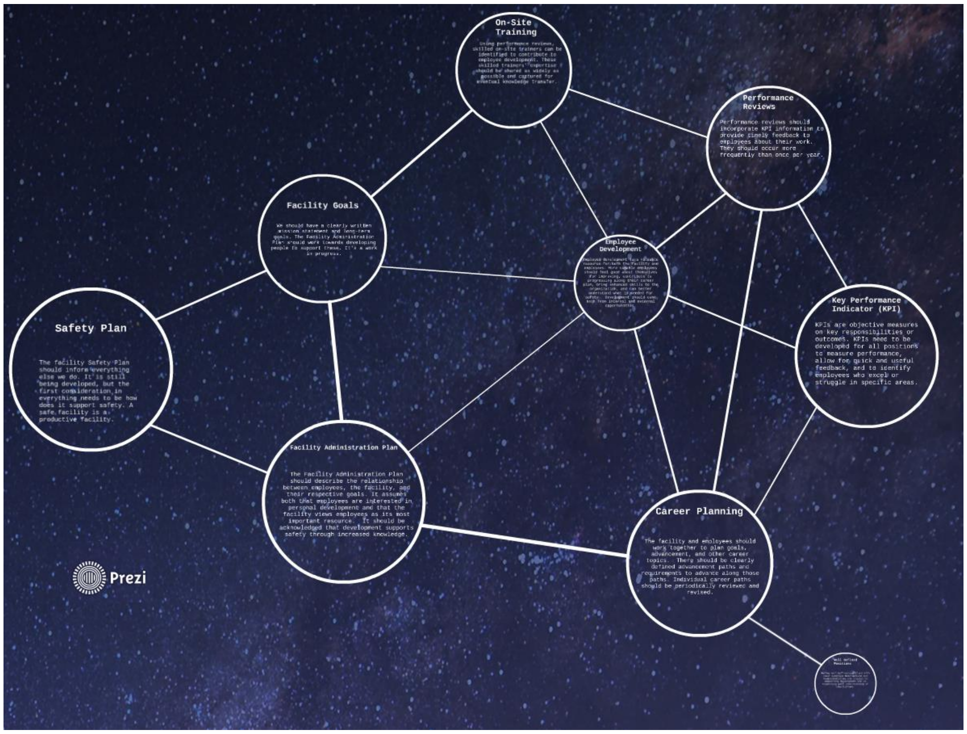

Figure 8: Administration Plan Web