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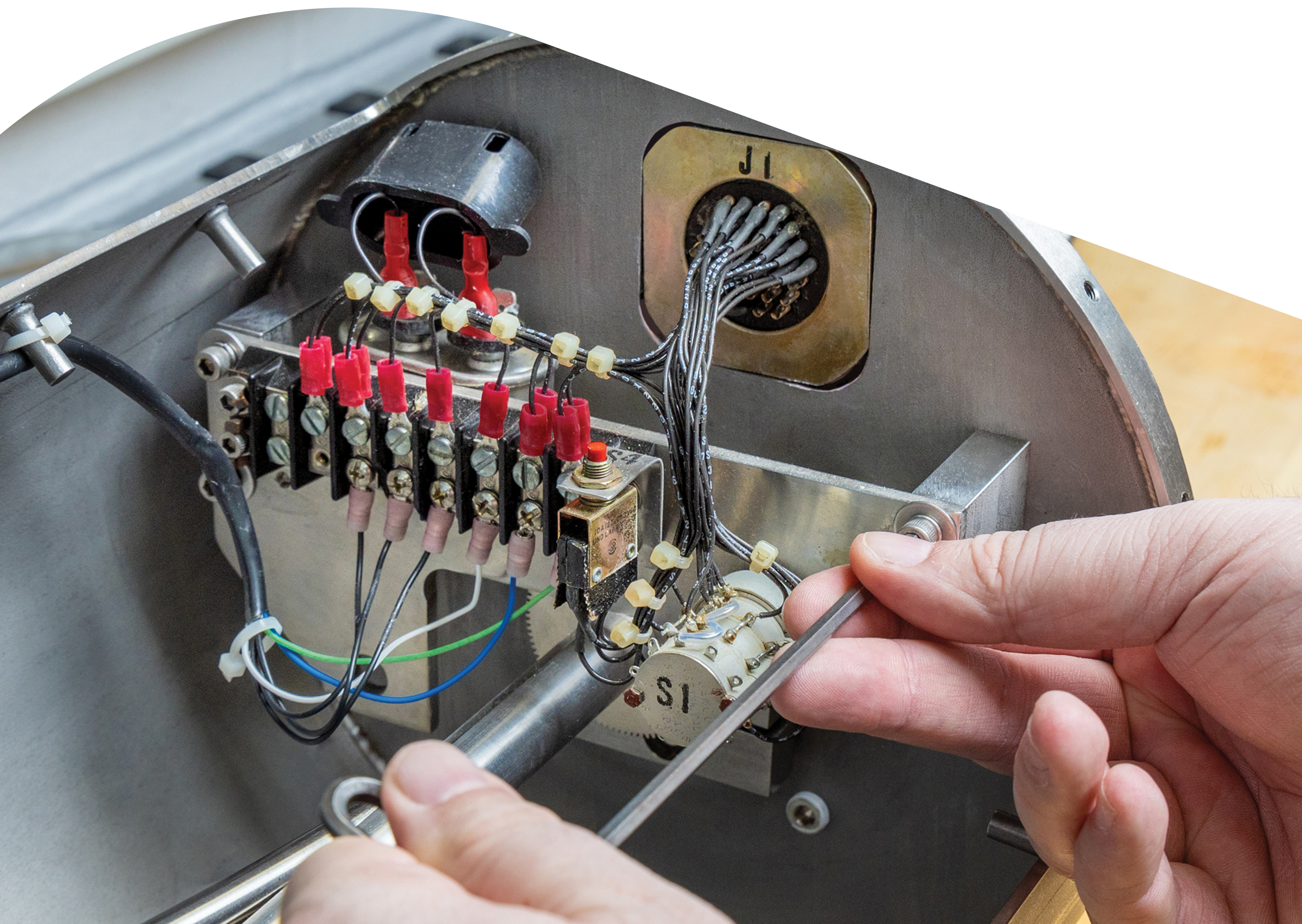
Modernizing Nuclear TIPs

Upgrading the traversing in-core probe system in Boiling Water Reactors



What's a **TIP?**

This white paper explores the limitations of the original traversing in-core Probe (TIP) system equipment and emphasizes the enhanced reliability and flexibility of an upgraded TIP drive system in Boiling Water Reactors (BWR).

It is designed to address key operational issues for nuclear industry stakeholders.

Local Power Range Monitors, or LPRMs, are miniature fission chambers used with local and average nuclear power range monitoring. They are calibrated using a traversing in-core probe, or TIP system, which utilizes a mechanical assembly called a drive mechanism to move the TIP detector into and out of the LPRM calibration tubes.

Calibrating TIPs

A typical boiling water reactor (BWR) has approximately three to five TIP systems to access each LPRM assembly. During regular operation, the TIP system periodically traverses the core to collect flux distribution data, measuring the neutron or gamma flux at the LPRM detector locations within the reactor. This data is required to compensate for LPRM sensitivity reduction due to burn up of the LPRM uranium plating.

Operating TIPs

Most current operating BWR plants have older TIP systems that must be calibrated periodically per the plant's technical specifications. If the core cannot be calibrated due to TIP system issues, it usually results in less-than-optimal fuel performance and sometimes a reduction in power level.

In response to these challenges and extensions in plant operation from 40 to 60 and now 80 years, there is a growing need to transition to the latest drive mechanism design that offers improved reliability and reduced maintenance time and resources.

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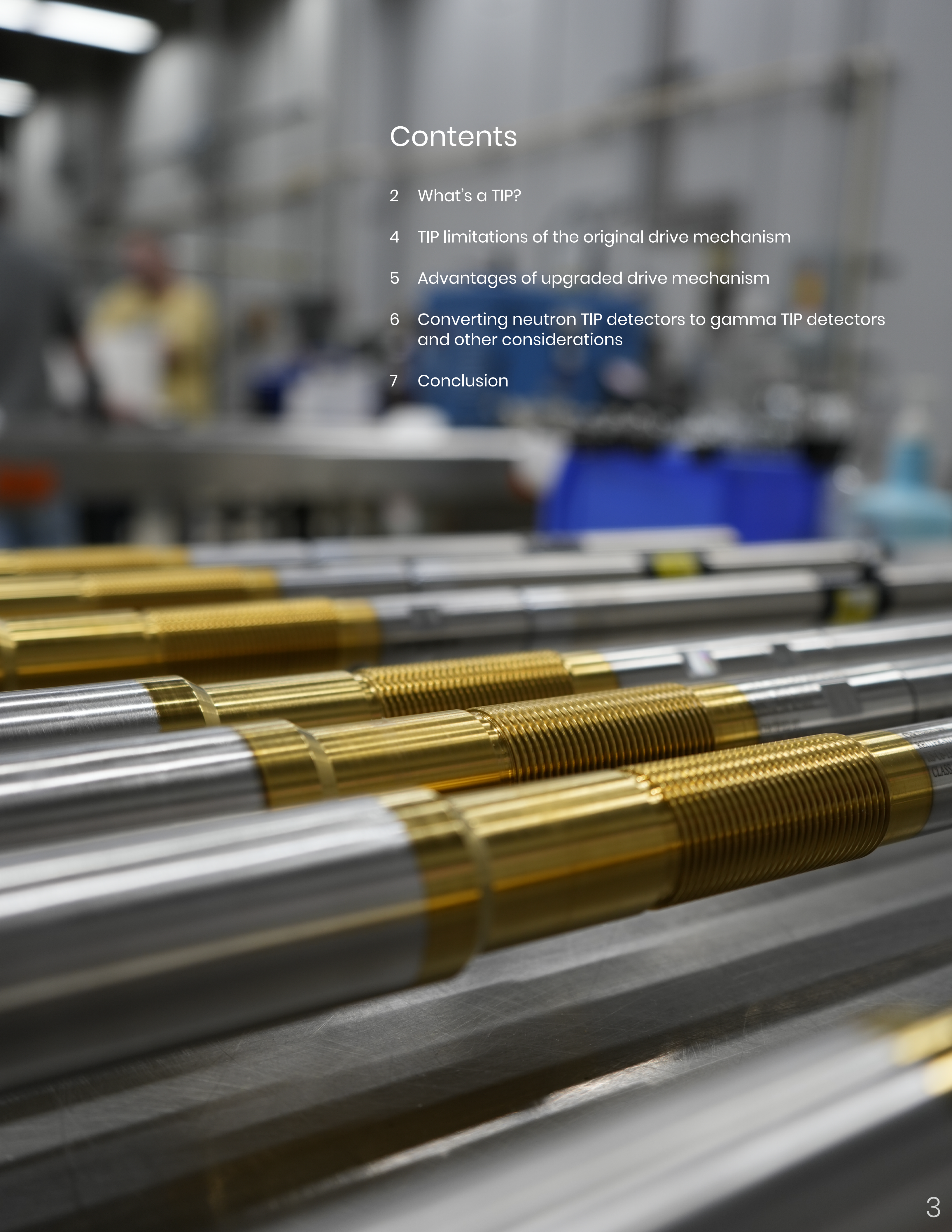
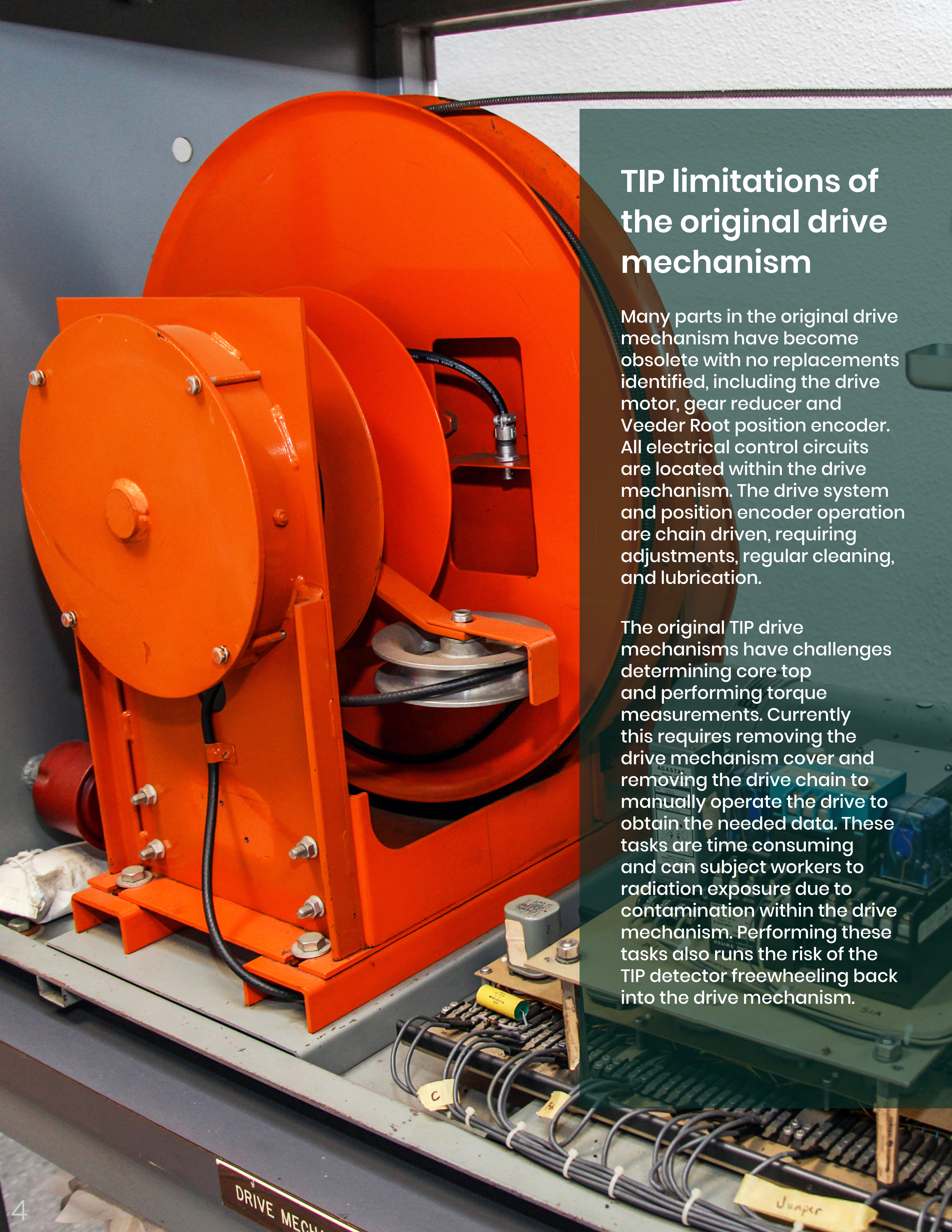




TIP limitations of the original drive mechanism

Many parts in the original drive mechanism have become obsolete with no replacements identified, including the drive motor, gear reducer and Veeder Root position encoder. All electrical control circuits are located within the drive mechanism. The drive system and position encoder operation are chain driven, requiring adjustments, regular cleaning, and lubrication.

The original TIP drive mechanisms have challenges determining core top and performing torque measurements. Currently this requires removing the drive mechanism cover and removing the drive chain to manually operate the drive to obtain the needed data. These tasks are time consuming and can subject workers to radiation exposure due to contamination within the drive mechanism. Performing these tasks also runs the risk of the TIP detector freewheeling back into the drive mechanism.

Advantages of an upgraded drive mechanism

Motor

Motor is direct drive.

Position encoder

Replaced with a gear-driven absolute encoder that is coupled to the drive motor, allowing better interface to new digital electronics and current technology.

Enclosure

Re-designed to be smaller and lighter.

Gear drive train

New design eliminates maintenance and adjustment of a chain drive (adjusting chain tension, cleaning and lubricating the chain, etc.)

Electrical drive controls

Moved to an external enclosure minimizing potential radiation exposure associated with the original design.

Torque

Torque information is read from the remote mounted control electronics (supplied by others) that provide continuous torque information whenever the drive is in use. The torque data can also be sent to an external computer from the control electronics.

Time and resources needed to obtain torque measurements for all TIP channels and core top settings is reduced to one shift and two technicians.

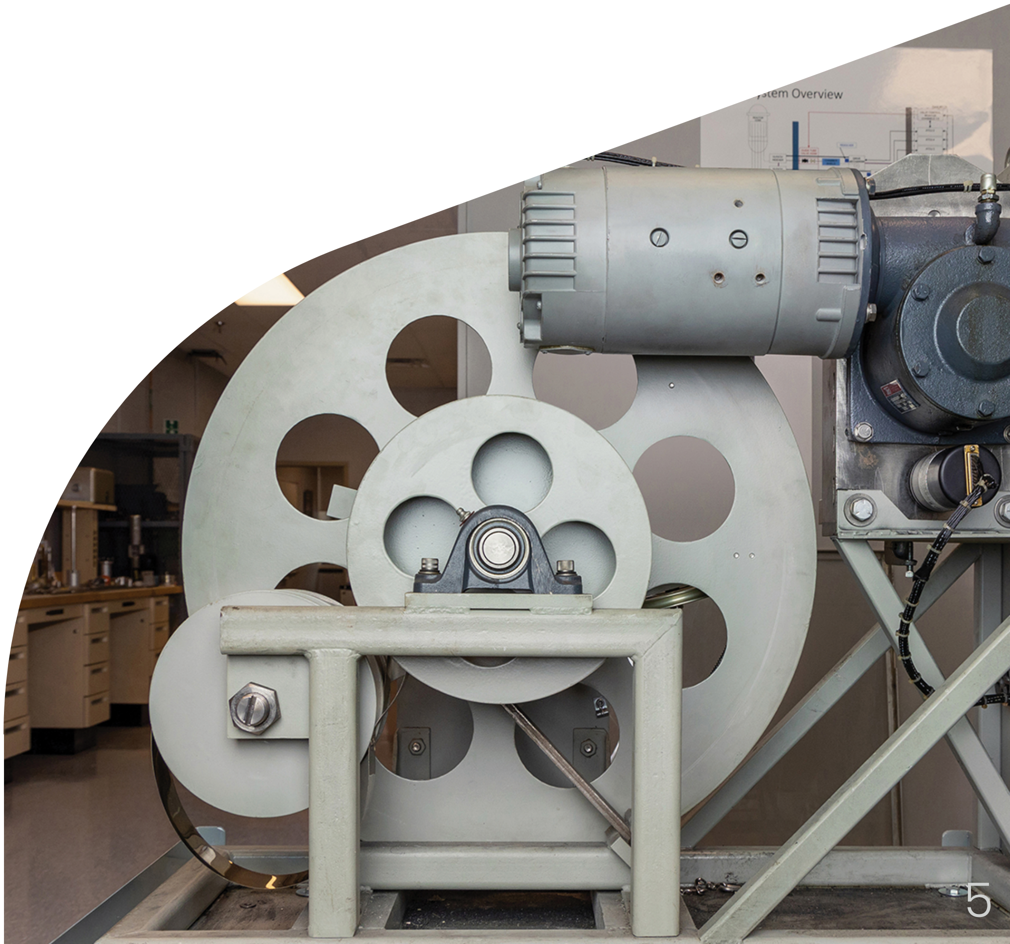
LPRM core top is determined from the control electronics torque display. The detector is motor driven to core top. The technician then uses the jog function to manually adjust the position of the detector using the control electronics to locate the physical top of calibration tube.

New motor direct drive and position encoder gear drive eliminates maintenance and adjustment of a chain drive (adjusting chain tension, cleaning and lubricating the chain, etc.)

Motor stop switch

De-energizes the motor if a runaway condition develops. A sacrificial beam provides a physical backup to the motor stop switch for increased reliability. The sacrificial beam deforms to dissipate the drive's rotational energy.

ADDED VALUE: Radiation protection resources are no longer required, as the drive mechanism does not have to be opened except for preventative maintenance.



Other considerations

Converting neutron TIP detectors to gamma TIP detectors

It has been proven that a gamma TIP detector is more accurate for measuring power level via gamma flux versus utilizing a neutron TIP detector that measures neutron flux. This results in smaller adjustments during LPRM calibrations, leading to better fuel utilization and ultimately cost savings to plants. A convenient time to convert to gamma TIPs is when a BWR is installing new TIP drive equipment.

Index mechanism

Some plants have older, rectangular index mechanisms. The newer, cylindrical-shaped design is more stiff (offering better resistance to torsion) and less susceptible to alignment issues. It's also easier to seal after inspection or maintenance. The old chain drive required frequent adjustments, was more sensitive to alignment and tension, and experienced additional wear. This is improved with the newer, direct gear drive train design.

Quick connect fittings

Quick connect fittings on the TIP tubing can provide time savings during an outage, or anytime that TIP tubing needs to be disassembled. **At one plant, a typical 12-hour TIP tube removal was reduced to one hour.**

TIP tubing and guide tube valve assembly

Some plants have considered replacing TIP tubing and equipment in the guide tube valve assembly. The TIP tubing ID is coated with a dry lubricant to reduce the TIP cable friction. Over time, the dry lubricant can flake off. This increases the system friction with less surface area lubricated and makes the drive system less reliable. The lubricant can also accumulate in the guide tube assembly, which can cause the solenoid valve not to function correctly.

Conclusion

The transition from the original TIP drive mechanism marks a critical improvement in the TIP system operation. For nuclear industry stakeholders, adopting upgraded TIP systems is not just an upgrade but a necessary evolution to meet future operational needs beyond the original 40-year plant life. Investing in these advanced monitoring systems means committing to a sustainable future in nuclear energy—where safety, efficiency, and technological advancement converge to power the world responsibly.

By leveraging these advancements and embracing the upgrades outlined in this white paper, the nuclear industry can significantly improve reactor monitoring and management, ensuring that it continues to play a vital role in meeting global energy needs safely and sustainably.

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