No.	Reference	Audit Questions	AMS Response
1	Abstract and Section 11.1 Pg. iii and 80	The "Abstract" topical report (TR) states: "This topical report describes how online monitoring [(OLM)] technology can be used in nuclear power plants as an analytical tool to measure sensor drift during plant operation and thereby identify the **sensors** whose calibration must be checked physically during an outage." [**emphasis** added] Furthermore, based on where (in the instrument channel) the sensor information is obtained, addition components, but not necessarily all components in the instrumentation channel, are also included in the comparison. Section 11.1, Step 1 states: "As a first step towards OLM implementation, a list of **transmitters** to be included in the OLM program must be developed." [**emphasis** added] The proposed TS markups generally include an insert in the "FREQUENCY" column of the "Perform CHANNEL CALIBRATION" surveillance requirements table. Generally, CHANNEL CALIBRATION includes more than just the sensors or transmitters. For example, the standard technical specifications (STS) include definitions for CHANNEL CALIBRATION such as: "A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. The CHANNEL CALIBRATION shall **encompass all devices in the channel required for channel OPERABILITY**. Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors may consist of an in-place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping, or total channel steps." [**emphasis** added] The Section 11.1, Step 1 list should also identify all other "devices in the channel required for channel OPERABILITY" that are subject to OLM. There should be an analysis that demonstrates the other devices included in the monitored signal do not invalidate the OLM methodology employed. How are the TS markups of the "Perform CHANNEL CALIBRATION" surveillance requirements to be understood? Only the sensors and transmitters are subject to condition-based calibration in accordance with the TR, and all other "devices in the channel required for channel OPERABILITY" are subject to the other FREQUENCY (e.g., periodic) requirements. That is, the implementation of the TS markups will always include two FREQUENCY criteria, if the condition-based calibration is used. Where will the explanation of how to understand the marked-up TS be documented?	The purpose of this TR is to seek NRC approval for: 1) OLM methodology to remotely determine if a transmitter as installed in an operating plant has drifted enough to need a calibration check, and 2) noise analysis methodology to determine if sensing lines leading from the process to the transmitter have developed a significant blockage. This TR is focused on nuclear plant pressure, level, and flow transmitters and their sensing lines. It is not intended to address the calibration of the rest of an instrument channel. The Surveillance Requirement frequency for other components in the signal path (e.g., risk-based, calendar-based, or digital I&C platform-based) should remain in effect. The Technical Specification markup presented in Appendix C were provided at NRC's request for examples of TS changes that may be needed. They are not provided as TS changes to be approved by the NRC. Section 11.4 provides explanations that are supported by examples in Appendix C.

No.	Reference	Audit Questions	AMS Response
2	Appendix A and Section 3.1	Appendix A addresses the implementation issues with the methodology described in Electric Power Research Institute TR-104965-R1-A. In the safety evaluation (SE), the NRC identified fourteen requirements that each licensee must address in any license amendment request (LAR) to extend transmitter calibration intervals using OLM. Appendix A of TR AMS-TR-0720R1 addresses the implementation issues associated with the fourteen requirements. The first of the fourteen requirements includes addressing "un-traceability of accuracy to standards" but this is not identified as an implementation issue; therefore, there is no solution provided in Appendix A. Please describe how this "requirement" is addressed.	This TR outlines an alternative methodology to that of EPRI's Topical Report TR-104965-R1-A (NRC SER). It is not intended to reflect on EPRI's methodology. Appendix A was included in the AMS-TR-0720-R1 at NRC's request in a pre-submittal meeting to clarify the difference between EPRI and AMS methodologies and establish why this new AMS TR is needed. The difference between AMS and EPRI methodologies is in the purpose of the methodology. The EPRI methodology is intended to verify the calibration of transmitters using OLM. In contrast, the AMS methodology is just a simple procedure to determine if a transmitter has drifted enough to need a manual calibration check which is performed using equipment with valid calibrations traceable to NIST.
		Section 3.1 of AMS-TR-0720R1 describes conventional calibration as a two-step process: (1) comparison of the sensor/transmitter to a traceable standard, and (2) sensor/transmitter adjustment if necessary (about 10% of the time). Effectively, the OLM methodology proposes to replace the comparison to a traceable standard with a comparison to redundant sensors/transmitters for the same process parameter; this replacement is justified in AMS-TR-0720R1 based on the fact that four sensors are unlikely (because it has not been observed to date) to experience common drift. Does this limit the applicability of the methodology to only when there are at least four redundant sensors? If one of the four sensors is declared inoperable[1], how is the methodology adjusted? If one of the four sensors drifts so far that it is excluded from the average, why is the methodology still applicable for the remaining three? Would this approach still be valid for a plant application that has only three redundant sensors?	OLM does not require 4-way redundancy. It can be used in services with 3 transmitters. If one of the redundant transmitters has drifted beyond pre-determined OLM limits, it is removed from the average and the remaining transmitters are averaged together to arrive at the process estimate. The parity space averaging technique that was reviewed by NRC as a part of EPRI's Topical Report TR-104965-R1-A is also used by AMS to identify the transmitters that must be removed before calculating the average. The AMS TR Section 6.3 provides an example as to how a drifting sensor is excluded from the average using the Parity Space averaging technique.

[1] Typically, Technical Specifications (TSs) include several types of SURVEILLANCE REQUIREMENTS such as CHANNEL CHECK, CHANNEL CALIBRATION, CHANNEL OPERATIONAL TEST, and ACTUATION LOGIC TEST. The topical report AMS-TR-0720R0 only proposes to change the FREQUENCY of the CHANNEL CALIBRATION for certain sensors/transmitters to be condition based. All other surveillances are unaffected and can result in a channel being declared inoperable.

No.	Reference	Audit Questions	AMS Response
2	Appendix A and Section 3.1	The NRC staff is aware of an instance at a US nuclear power plant where three (of four) sensors experienced common-mode drift. The NRC staff is also aware of the setpoint of 6 differential pressure switches serving as Reactor Water Level Narrow Range function have all shifted from their previously calibrated settings by approximately the same amount in the same direction due to a systematic effect resulting from the design of the instrument (See NRC Bulletin BL 86-02 and Information Notice IN 86-47). However, Section 3.3, "Common Mode Drift," claims that common mode drift has not been seen. The NRC Staff's understanding of the OLM methodology described in the SE of the year 2000 states: "At least one redundant sensor will be calibrated each scheduled fuel cycle. For n redundant sensors, all sensors will be calibrated at least once in every n outage… In addition to calibrating at least one redundant sensor each scheduled fuel cycle, sensors that are identified as out-of-calibration by the on-line monitoring process will also be calibrated as necessary… By proposing to change the TS required instrumentation calibration frequency from the current once-per-refueling-cycle to a maximum of "once every 8 years based on the results of performance monitoring using the on-line monitoring technique," the topical report basically proposes to replace the current "time-directed traditional calibration" with the "on-line monitoring and calibrate-as-required approach," with an interval between the two successive calibrations limited to a maximum duration of eight years." The purpose of NUREG-0800, Branch Technical Position (BTP) 7-13 Rev. 6, "Guidance on Cross-Calibration of Protection System Resistance Temperature Detectors," is to identify the information and methods acceptable to the staff for using cross-calibration techniques for surveying the performance of resistance temperature detectors (RTDs). This BTP contains acceptance criteria similar to the previous SE. Will all proposed implementations of OLM that reference AMS-TR-0720R1 be implemented in accordance with this understanding that at least one of a group of X redundant sensors be calibrated against a known standard at least once per refueling outage? If so, would the calibration of a group of four redundant channel sensors rotate each refueling outage to a different sensor, such that each of the four sensors are calibrated to a known standard at least once every 8 years? The TR needs to clarify this issue and provide a basis for any significant deviations from the OLM methodology in the previous SE approval.	Bulletin 86-02 and Information Notice 86-47 are concerned with common mode drift in specific models of Static-O-Ring pressure switches; not pressure transmitters. The AMS TR is concerned with nuclear grade pressure transmitters which have been shown through drift studies and analysis of actual plant data to suffer no common mode drift. The AMS TR addresses common mode drift using 11 cycles (15 years) of transmitter calibration data from Sizewell plant in addition to drift studies of transmitter calibrations performed by EPRI and others which also found no evidence of common mode drift. The AMS methodology in the TR does not mandate that one transmitter from each redundant set be calibrated at each refueling outage. To date, sufficient experience has been accumulated from OLM implementation at nuclear facilities to substantiate the AMS claim that no transmitters from each set of redundant transmitters must be calibrated unless found by OLM to need a calibration check. BTP-7-13 Rev. 6 references NUREG-CR 5560 dated June 1990 which AMS wrote for the NRC based on a research project involving nuclear grade RTDs. This project demonstrated that nuclear grade RTDs do not suffer from common mode drift. An identical study was not done for pressure transmitters but a great volume of industry data has shown that pressure transmitters do not suffer common mode drift.

No.	Reference	Audit Questions	AMS Response
3	Section 3.3	An argument is made in Section 3.3 of the TR that common mode drift is not a credible failure mode. This argument is based on calibration data collected at several plants over a ten-year period. Because this data is based on observations made over a finite period, the results cannot support use of an unlimited calibration intervals. The argument used in the TR is based on data from transmitters that are frequently checked for calibration. This data does not indicate drift levels over extended periods of time (i.e., significantly greater than ten years) and the probability of common mode drift becomes greater over time. If there is no maximum calibration interval, then the probability of common mode transmitter drift is indeterminate. In absence of a maximum calibration interval, an infinite amount of transmitter data would be required to demonstrate that common mode drift is not credible for the entire service life of the transmitters. If a statistical analysis is the basis for eliminating the possibility of common mode transmitter drift, then a maximum calibration interval for the process group must be established.	The arguments in AMS-TR-0720R1 relating to common-mode drift are based on: 1) calibration data which were collected over the period of 1990-2010 at more than 40 nuclear power plants, and 2) OLM results for Sizewell transmitters over 11 cycles (15 years from 2002-2017) which have shown no evidence of common mode drift as verified by manual calibrations (Section 10.1.5 of AMS Topical Report).
4	Section 3.4	Calibration typically addresses drift and failure modes, and linearity, responsiveness, pressure offset, and hysteresis. Please describe how the OLM program addresses linearity, responsiveness, pressure offset, and hysteresis.	OLM identifies transmitters that have drifted enough to need a calibration check. The calibration of such transmitters are then checked using equipment with valid calibration traceable to NIST and with procedures that account for linearity, responsiveness, pressure offset, and hysteresis.
5	Section 3.4.1 pg. 12	The TR states: "Force-Balance Transmitters: FMEA analysis of these transmitters identified fourteen possible failure modes; all but one of which are detectable by OLM. Of these, nine can be detected by OLM during **normal plant operation**, one during **transient operation**, and three during either modes of operation. The single failure mode that cannot be detected by OLM is a change in viscosity of the fill fluid; usually caused by changes in environmental conditions (e.g., temperature or radiation)." [**emphasis** added] However, the TR does not define or describe normal or transient operation for the various applications (e.g., RWST level) or require that OLM is performed during all the manners or operation that are required to detect the failure modes. Furthermore, the sensor range may significantly exceed the process variable range during operation which may lead to greater uncertainty than can be achieved during calibration (e.g., containment pressure).	OLM data taken during plant startup and shutdown or other plant transients can be analyzed to identify transmitter drift over much of its span. This claim has been substantiated through comparison of OLM and manual calibration results for Sizewell B transmitters over 11 operating cycles (2002-2017), each involving nearly 200 transmitters.

No.	Reference	Audit Questions	AMS Response
6		In empirical, model-based OLM, current measurements are applied to an algorithm that uses historical plant data to predict the plant's current operating parameter values. The deviation between the algorithm's predicted parameter values and the measured plant parameters is used to detect any instrument faults, including instrument drift. Many algorithms can be used to accomplish OLM, for example: auto-associative neural networks, auto-associative kernel regression, and auto-associative multivariate state estimation technique. However, the AMS TR on OLM does not mention that OLM is model-based or what particular algorithm is used to predict plant parameter values. This TR implies that only the two "averaging" techniques explicitly discussed can be used to determine the plant parameter value used for determining sensor/transmitter drift and that noise from individual sensors/transmitters is used to determine associated instrument tube fouling. Please clarify.	This TR is seeking approval for parity space and simple averaging techniques to estimate the process value and for noise analysis technique to identify sensing line blockages. The OLM methodology described in Section 11 of this TR is intended to be agnostic to the algorithm/technique used to provide a process estimate. Other process estimation techniques will need to be identified in a license amendment request to obtain NRC approval to be used with the OLM methodology described in this TR.
7	Section 1.1 pg. 1	"Based on its review of the information presented in WCAP-13632, Revision 2, the staff has concluded that any sensor failure that significantly degrades sensor response time can be detected during the performance of other surveillance tests, principally calibration. Accordingly, the staff concludes that the performance of periodic RTT for the selected pressure and differential pressure sensors identified in the topical report can be eliminated from Technical Specifications (TS) and that allocated sensor response times may be used to verify acceptable RTS and ESFAS channel response times. Therefore, the staff accepts WCAP-13632, Revision 2, for reference in license amendment applications for all Westinghouse pressurized water reactors with the conditions discussed below." The AMS OLM TR states: "Online monitoring (OLM) technologies have been developed and validated for condition monitoring applications in a variety of process and power industries. These applications include: 1) optimized maintenance of instrumentation and control (I&C) systems including online drift monitoring and in-situ response time testing of sensors, 2) detection of blockages, voids, leaks, and flow anomalies in operating processes, and 3) identification of excessive vibration, overheating, and equipment or process deviations from normal behavior [1-7]. However, this report is focused on the application of OLM for monitoring drift of pressure, level, and flow transmitters in nuclear power plants."	OLM detects sensing line blockages or other response time-related failure modes using the noise analysis technique for transmitters that are exposed to sufficient process fluctuations. However, this TR does not propose any changes to NRC-approved elimination of Response Time Testing requirements.

No.	Reference	Audit Questions	AMS Response
7	Section 1.1 pg. 1	However, Section 3 describes which failure modes are detectable with response time testing and/or OLM. So, even though OLM does not support response time testing, it detects most of the failure mode that would be detectable by response time testing. Clarify if this is the correct intent. Some process parameters may be steady or change very slowly (when compared to expected instrument response times). For these process parameters, how does OLM detect the failures that are detectable by response time testing?	For the transmitters that are not exposed to process fluctuations with adequate amplitude or bandwidth, sensing line blockages can still be identified remotely by injecting artificial process fluctuations into the pressure sensing system using a pressure signal generator. This method has been validated by AMS and used for testing of hundreds of transmitters in nuclear power plants.
8	Appendix A pg. A-1	Appendix A, “OLM Implementation Issues with [SE] of year 2000 and Proposed AMS Solutions,” states: “the methodology described in the [SE] of the year 2000 contains several issues identified by the industry ... In this section, the fourteen requirements from the [SE] are listed in Table A.1 along with the implementation issue[(s)] with each requirement, and the proposed solution from the OLM methodology implementation described in this report.” This quotation implies that the OLM Implementation proposed by a licensee will be in accordance with ERPI TR-104965-R1-A as augmented and supplemented with the solutions of the “implementation issues” provided in AMS-TR-0720R1; however, this is not explicitly stated in AMS-TR-0720R1. Is this correct? Are there any aspects of ERPI TR-104965-R1-A which are not going to be implemented?	As a point of clarification, the AMS TR is new and is meant to stand on its own with no relationship to EPRI’s TR or EPRI’s methodology. The methodology described in the AMS TR is an alternative methodology to that of EPRI in EPRI TR-104965-R1-A. Appendix A in the AMS TR discussing the EPRI Topical Report was included in response to NRC’s request from a pre-submittal meeting as to why this new AMS TR is needed.

No.	Reference	Audit Questions	AMS Response
9	Appendix A pg. A-1	The docketed TR states: "A [Safety Evaluation (SE)] on the EPRI OLM implementation methodology was published in July 2000 [A1]. In the SER, the NRC identified fourteen requirements that each licensee must address in any license amendment request (LAR) to extend transmitter calibration intervals using OLM. In 2006, a nuclear power plant submitted an LAR for extending transmitter calibration intervals that addressed the fourteen requirements. The NRC responded with questions on how the licensee addressed some of the requirements, and the LAR was subsequently withdrawn in mid-2006 after meetings between the NRC and the licensee [A2 - A4]." This quotation implies that industry and NRC staff had different expectations about the material to be included in a LAR. (To avoid a repeat, it may be efficient to agree on, roughly, what information is expected to be included within a LAR.). In addition, it is not clear, from the contents of the TR, what a LAR should include. Perhaps a model LAR should be included as an Appendix to support the request to review the TR.	We agree that clarity on the expectations is necessary as a lesson learned from the implementation attempts with EPRI TR-104965-R1-A. AMS provided the implementation methodology in Section 11 to directly address this issue. Therefore, we expect that any LAR based on this TR will use the methodology in Section 11. A model LAR is part of the TSTF process according to LIC-600 R1. This TR is not providing a TSTF; instead, it is submitted for approval under LIC-500 R8, which does not include a model LAR process.
10		This TR should list (or clearly characterize) the sensors/transmitters to which the OLM described in the TR could be applied. Alternatively, if a new type of sensor/transmitter is to be added, there is no description of the process to do so; for example, if a sensor/transmitter in the program is replaced with a different type (i.e., one not on the approved list), then how does the program deal with this?	The OLM methodology in this TR is agnostic to transmitter type, model, or manufacturer. In this methodology, the manufacturer's drift specifications for each transmitter type are used to arrive at OLM limits. This is how differences between transmitter designs and manufacturers are accounted for in the AMS methodology. The OLM analysis algorithms of simple and parity space averaging are not dependent on the type(s) of transmitters or the processes that the transmitters are measuring. For any new transmitter designs that have not been involved in previous drift studies and have no historical calibration data, a like-for-like similarity analysis should be performed to determine whether or not common mode drift can be ruled out.

No.	Reference	Audit Questions	AMS Response
11	Appendix C	An NRC approval of this TR can serve as a generic basis for site-specific LARs. The STS mark-ups are included in the TR to provide an example of changes which should be supported by justifications in the TR. These TS changes are however not proposed changes as formal changes to the STSs. The current position of the NRC staff is not to approve the specific mark-ups as absolutely allowable TS for licensee's referencing this TR (e.g., in a similar manner of a TS traveler to the STS). Each licensee will need to perform a site-specific evaluation of both its licensing basis and site-specific TS, and can propose changes using, in part, the generic technical basis in the TR and considering the generalized TS examples in the TR to the extent applicable.	The Technical Specification changes illustrated in Appendix C are provided at NRC's request as an example of the changes that may be needed. They are not provided as TS changes to be approved by NRC.
12	Section 3.3 Pg. 9	Common Mode Drift Characterizations - The discussion of Common Mode Drift includes an argument that observed drift is statistically random. The following statement is made to support this: "This figure shows that the drift of a group of transmitters in the same service over a long period of time (e.g., ten years) is randomly distributed in the positive and negative directions above and below the mean value of the drift." Has any test for normalcy been done on the data used to support this claim? NUREG-1475 includes several tests for normalcy methods that could be applied to the data. See Chapter 11, "Goodness-Of-Fit-Tests." The results of these tests could be used to verify or confirm the conclusions made in the TR.	The data used to support this claim has been tested for normalcy using either the D' test or the W test as specified in NUREG-1475 and the EPRI 3002002556 "Statistical Analysis of Instrument Calibration Data Rev 2," page 8-5.
13	Section 3.5 Pg. 16	Noise Analysis Techniques - Process Dynamics - OLM methods for determining transmitter responsiveness are highly dependent on the dynamic characteristics of the process being measured. Highly stable processes may therefore require higher sample rates to establish an equivalent level of confidence in transmitter responsiveness when compared with transmitters measuring more dynamic processes. Is there a method of measuring or classifying process dynamic characteristics for the purpose of determining the sample rates needed to verify transmitter responsiveness? Does the method include a formula or curve that could be used to determine the required sample rates for transmitter responsiveness determinations? For very stable processes, it may not be possible to use OLM to verify transmitter responsiveness. In such cases, how will transmitter responsiveness be confirmed if TR tests are not to be performed?	This is addressed in TR Section 11.2 item number 3. "To determine if a transmitter is amenable to noise analysis, high frequency data is collected and analyzed to evaluate if the process fluctuations are driving the pressure sensing system to its full dynamic range. Collecting noise data at 2000 Hz for 1 hour will cover the entire dynamic range of typical pressure sensing systems in nuclear power plants." "For services such as containment pressure that do not fluctuate much, a random signal generator can be used to apply wideband pressure noise into the transmitter's sensing system to produce adequate fluctuations at the transmitter output for noise analysis."

No.	Reference	Audit Questions	AMS Response
14	Section 10.3 Pg. 77	Transmitter Span Verification using OLM - Shifts in a transmitters span setting are detected by OLM during monitoring activities during plant transient conditions such as a plant cooldown and depressurization. The effectiveness of detecting span problems in a transmitter depends upon the amount of the transmitter range that is exercised during the plant transient. For processes that can be monitored over a high percentage of the operating range of the transmitter, a high degree of confidence that span calibration is correct can be achieved. However, for instruments measuring processes that only can be exercised over a small percentage of the instrument range, a lower degree of confidence will be achieved. What is the acceptance criteria for the amount of range achieved during OLM during transient activities in order to establish that a transmitter span calibration is acceptable?	The TR does not include acceptance criteria as to how much of a transmitter's range must be covered by OLM. The methodology in the TR assumes that nuclear grade pressure transmitters are predominantly linear. This assumption is substantiated with 15 years of data from Sizewell B plant yielding over 99% conservative agreement between the results of manual calibrations and OLM.