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Activation Analysis
Coolant Chemistry
Nuclear Medicine
Reactor Engineering

November 21, 2001

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
Attn: Document Control Desk

Subject: License Amendment for MIT Research Reactor, License No. R-37, Docket No. 50-20, Technical Specification No. 6.6 – "Design and Operation of the Fission Converter Facility"

Gentlemen:

The Massachusetts Institute of Technology hereby submits a request to amend its operating license (R-37) to modify Fission Converter surveillance requirements and eliminate unnecessary procedures, in accordance with ALARA considerations. Enclosed please find: Proposed modification of MITR Technical Specification No. 6.6.3, "Fission Converter Surveillance Requirements".

Please contact either the undersigned should further information be required. This request has been reviewed and approved by the MIT Committee on Reactor Safeguards.

Sincerely,

Thomas Newton, P.E.
Reactor Engineer
MIT Nuclear Reactor Laboratory

John A. Bernard, Ph.D.
Director
MIT Nuclear Reactor Laboratory

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 11-21-01 _____
Date Signature

JAB/gw

cc: USNRC - Senior Project Manager, NRR/ONDD
USNRC - Region I - Project Scientist, Effluents Radiation Protection Section (ERPS)+ FRSSB/DRSS

A020

a. Neutron flux level channel,

b. Primary coolant flow channel, and

c. Primary coolant outlet temperature channel.

3. The neutron flux level channel and a fission converter primary system heat balance shall be checked against each other at least annually and when design changes in the reactor and/or the fission converter are made that may affect the existing calibration result.

4. The gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

Basis

The specifications for functional tests, calibrations, and primary coolant sampling adhere to current MITR practice.

The annual frequency for performance of the calorimetric was chosen because the fission converter's power is a function of the MITR's power and the burnup of the fission converter fuel. The latter will occur very slowly. Hence, the annual performance of a calorimetric is sufficient to detect any change in fission converter power production.

Experience with the MITR primary and D_2O systems has shown that an out-of-specification chemistry condition is extremely rare. Heat fluxes present in the fission converter are too low to contribute to fuel cladding degradation in the event of out-of-specification chemistry. Continued operation of the fission converter is thus permitted.

Safety Review #-0-01-8 – Changes to MITR Technical Specification 6.6.3

The following changes to MITR TS 6.6.3 are proposed:

Specification 2(d) The Fission Converter (FC) tank coolant level channel provides a reactor scram and CCS closure if the FC coolant drops below 2.1 m above the top of the fuel. The level probe (a float switch, vendor's diagram attached) is set to activate at 2.2 m above the top of the fuel. This position is not adjustable. Any significant positioning changes would occur only if the switch were to become detached from its position. If this were the case, the level probe functional test as required in TS 6.6.3.1 would indicate the malfunction.

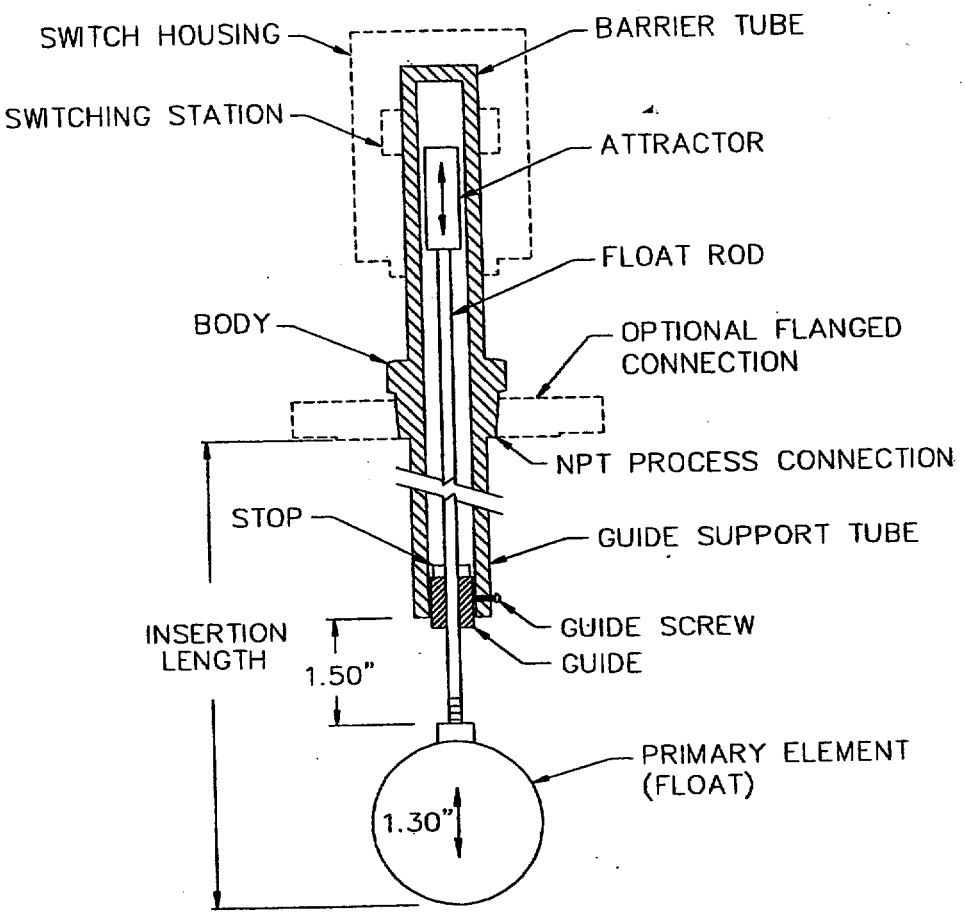
A calibration, as required in TS 6.6.3.2, is very difficult in that the FC top shielding and lid cover must be removed, D_2O slowly removed from the FC tank, and the level measured. This requires significant manpower and personnel dose to measure an activation level which cannot change. It is therefore proposed to eliminate TS 6.6.3.2(d). It should be noted that TS 6.6.3.1 remains unchanged and it requires, among other things, an operability check of the FC tank coolant level channel. Hence, the proposed elimination of TS 6.6.3.2(d) does not decrease safety. Operability of the level channel is still assured via testing. The only change is to eliminate a calibration requirement that is both difficult to perform and wasteful of D_2O, and which provides no benefit because the probe's position isn't subject to gradual change. The only possible failures in design are abrupt and those are detected by the functional test.

Specification 4 Since the FC coolant is high purity D_2O, and is continually circulated through a cleanup loop, the ionic strength of the D_2O is very weak, making pH measurements difficult. In addition, pH measurements result in above 10 ml of D_2O being wasted each month. A low conductivity would also mean that the pH must be near 7.0 (see attached memo from G. Kohse). Typical FC conductivity readings are about 0.06 μS/cm. These readings are taken prior to FC operation, with the temperature never exceeding 35 °C. It is proposed to change the wording of T.S. 6.6.3 as follows:

4. The gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample.

The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

Model 709 Level Switch Float and Body Top-Mounted, One Switch Station



OPERATION

The Model 709 provides switch action at a selected elevation of a varying liquid level. The unit is located on top of the vessel with the primary element extending down into the vessel. The float rides on the surface of the liquid and is carried up and down as the liquid level varies. The attractor is coupled to the float by the float rod and also moves up and down as the level varies. The attractor is located inside of the barrier tube and is in contact with the process fluid. The switching stations are located on the outside of the tube and are isolated from the process fluid. Each station contains a magnet which is magnetically attracted to magnetic materials such as the attractor. The magnet is pulled in against the barrier tube as the attractor rises to the position of the magnet. The magnet is connected to an output dry contact switch which operates as the magnet is pulled in against the barrier tube. From 1 to 4 separate SPDT switches are simultaneously operated. The guide is always located just above the float. This improves reliability by helping to prevent rod bending, binding, and "hangups".

INSTALLATION

The Model 709 should be mounted vertically on top of the vessel. The guide tube/float rod must be long enough so that the float centerline extends down approximately 2" below the point where switch action is desired. A baffle or stilling well is required if the liquid is agitated or has surface turbulence; otherwise, erratic operation may result. The switching point is fixed by the length of the guide tube/float rod. The process connection should be large enough to admit the float into the vessel. If it is not, then the float must be unscrewed from the float rod and installed from inside the vessel after the body/attractor assembly has been mounted on top of the vessel.

MIT-NRL

Fission Converter Beam Group

MEMORANDUM

To: QA File M-97-3

From: G. Kohse

Date: February 16, 2001

Subject: **pH and Conductivity Measurement in the FCB D_2O System**

This memo documents calculations that form the basis for reducing the frequency of pH measurements in the FCB primary coolant system, if certain conditions are met.

The technical specifications for the FCB primary coolant system give a range of acceptable pH and conductivity values. Conductivity is measured on line while pH must be measured using a batch sample. The pH measurement is difficult to perform accurately because of the weak ionic strength of the pure D_2O coolant and the absorption of CO_2 from the atmosphere once the batch sample is taken. Reasonable results have been achieved using a commercially available kit to adjust the ionic strength. However, the added chemicals and the potential of contamination with other ions leached from the pH electrode preclude returning the pH samples to the system. The pH measurement therefore creates a small but significant stream of waste D_2O.

The conductivity measurement, which is made on-line and does not involve the same difficulties as the pH measurement at low ionic strengths, can be related to a probable range of pH and thus reduce the need for batch sampling. The calculation presented here uses data for H_2O, which is readily available in standard references. Although the values for heavy water are not expected to be markedly different, the calculation should be repeated using D_2O data if it can be obtained.

Consider a case where an acidic species is added to pure water. The ions present are H^+, OH^-, and anions contributed by the acid X^- (Cl^- in the case of HCl, for example). Using the dissociation constant for water, the hydrogen and hydroxide ion concentrations can be related to each other:

$$[H^+][OH^-] = 10^{-14} \qquad (1).$$

Furthermore, the conductivity (μ, units S/cm) contributed by each of these species can be calculated from the equivalent molar conductance (λ, units S/cm/mol/l):

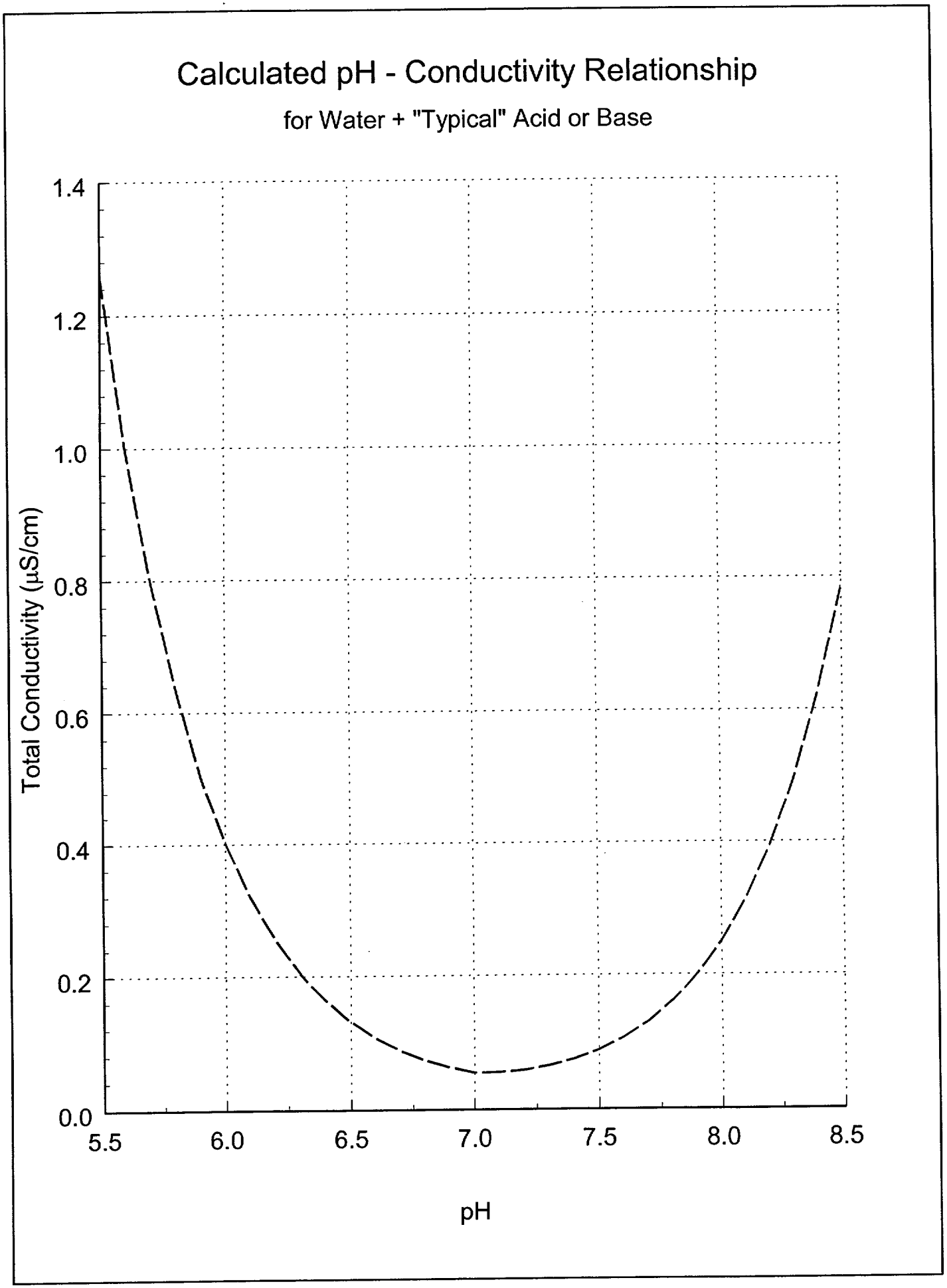
$$\mu = \lambda [M]. \qquad (2)$$

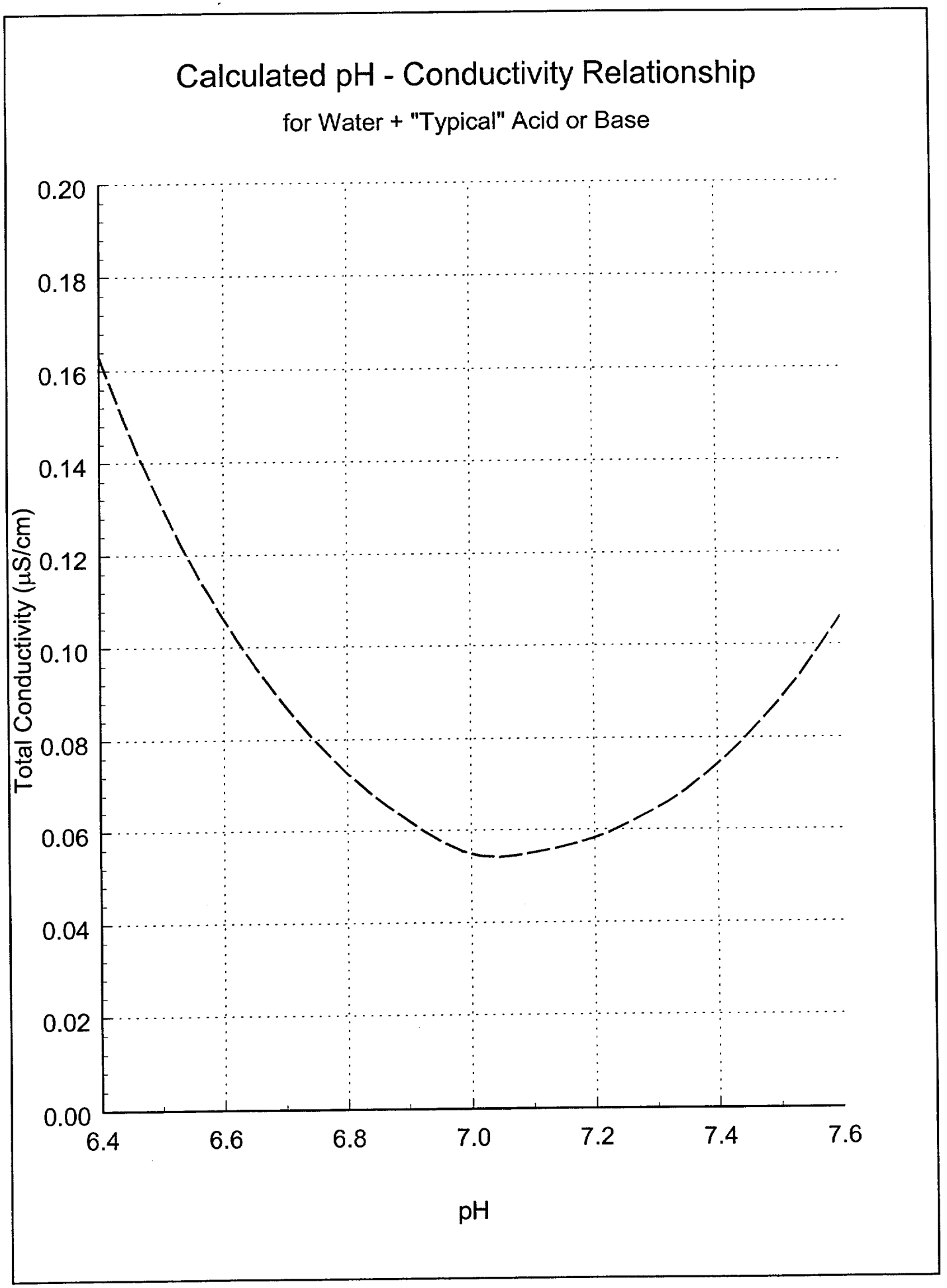
Table 4-19 on p.99 of *Handbook of Power Plant Chemistry*, Hans-Gunter Heitmann, CRC Press, Boca Raton, 1993, gives values of λ of 349.8 x 10^{-3} for H^+ and 198 x 10^{-3} for OH^-. The table also shows that most common acidic anions have equivalent molar conductance of about 70 x 10^{-3}. Using a more conservative value of 50 x 10^{-3} for the equivalent conductivity of a potential acidic anion, the total conductivity can be calculated for any pH less than 7 by recognizing that $[X^-] = [H^+]-[OH^-]$, calculating $[OH^-]$ from equation (1) and summing the conductivity contributions of each of the three species. That is, for pH<7:

$$\mu(pH) = \lambda(H^+)x10^{-(pH)} + \lambda(OH^-)x10^{(pH-14)} + \lambda(X^-)x(10^{-(pH)}-10^{(14-pH)}) \quad (3)$$

An analogous calculation can be made for a contaminating base, and Table 4-19 again shows that a value of 50 x 10^{-3} for the equivalent conductivity of a potential basic cation is reasonable.

The attached figures plot the conductivity – pH relationship obtained by this procedure, first for the pH range 5.5 – 8.5 and then an expansion of the region from pH 6.4-7.6. To use the figures to establish a probable pH range for any given conductivity, simply draw a horizontal line at the conductivity value and note the x-intercepts of this line on the curve. If ionic species are present which do not affect the pH, the actual pH range would be represented by a lower conductivity value and hence would be closer to neutral. For example, if the conductivity is measured to be 0.06 μS/cm, the pH must lie between about 6.9 and 7.2. It is therefore unnecessary to do a batch pH measurement to confirm that pH is within the allowable limits, particularly if no change in conductivity has been observed since the most recent pH measurement.


Calculated pH - Conductivity Relationship
for Water + "Typical" Acid or Base
Total Conductivity (µS/cm)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
pH


Calculated pH - Conductivity Relationship
for Water + "Typical" Acid or Base
Total Conductivity (µS/cm)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
6.4
6.6
6.8
7.0
7.2
7.4
7.6
pH

6.6.3 Fission Converter Surveillance Requirements

Applicability

This specification applies to the surveillance of safety systems whose operation is important to fission converter safety.

Objective

To assure the reliability of the instrumentation important for safe operation of the fission converter.

Specification

1. The following instruments or channels for the fission converter safety system will be tested at least monthly and each time before startup of the reactor if the reactor has been shut down more than 16 hours and if the fission converter facility will be used within that reactor operating period. The monthly requirement may be omitted if the fission converter facility will not be used during that month.

Instrument, Channel, or Interlock	Functional Test
Primary coolant flow	Automatic converter control shutter closure and reactor scram
Power level	Automatic converter control shutter closure
Primary coolant outlet temperature	Automatic converter control shutter closure
Fission converter tank coolant level	Automatic converter control shutter closure and reactor scram

2. The following instruments used in the fission converter facility shall be calibrated and trip points verified when initially installed, any time the instrument has been repaired, and at least annually:

a. Neutron flux level channel,

b. Primary coolant flow channel, and

c. Primary coolant outlet temperature channel.

3. The neutron flux level channel and a fission converter primary system heat balance shall be checked against each other at least annually and when design changes in the reactor and/or the fission converter are made that may affect the existing calibration result.

4. The gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

Basis

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Experience with the MITR primary and D_2O systems has shown that an out-of-specification chemistry condition is extremely rare. Heat fluxes present in the fission converter are too low to contribute to fuel cladding degradation in the event of out-of-specification chemistry. Continued operation of the fission converter is thus permitted.

a. Neutron flux level channel,

b. Primary coolant flow channel, and

c. Primary coolant outlet temperature channel. ~~and~~

~~d. Fission converter tank coolant level channel.~~

3. The neutron flux level channel and a fission converter primary system heat balance shall be checked against each other at least annually and when design changes in the reactor and/or the fission converter are made that may affect the existing calibration result.

4. The ~~pH and~~ gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

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