3.5 INSTRUMENTATION SYSTEMS

Operational Safety Instrumentation

Applicability

Applies to plant instrumentation systems.

Objectives

To provide for automatic initiation of the Engineered Safety Features in the event that principal process variable limits are exceeded, and to delineate the conditions of the plant instrumentation and safety circuits necessary to ensure reactor safety.

Specifications

3.5.1 When the plant is not in the cold shutdown condition, the Engineered Safety Features initiation instrumentation setting limits shall be as stated in Table 3.5-1.

3.5.2 For instrumentation channels, plant operation at rated power shall be permitted to continue in accordance with Tables 3.5-2 through 3.5-4. No more than one channel of a particular protection channel set shall be tested at the same time. By definition, an instrumentation channel failure shall not be regarded as a channel being tested.

3.5.3 In the event the number of channels of a particular function in service falls below the limits given in the column entitled Minimum Operable Channels, or Minimum Degree of Redundancy cannot be achieved, operation shall be limited according to the requirements shown in Column 5 or 6 of Tables 3.5-2 through 3.5-4. For on-line testing or corrective maintenance of instruments with installed bypass capability, the required minimum degree of redundancy may be reduced by one to permit testing or corrective maintenance of a channel in bypass.

3.5.4 In the event of sub-system instrumentation channel failure, Tables 3.5-2 through 3.5-4 need not be observed during the short period of time the operable sub-system channels are tested where the failed channel must be blocked to prevent unnecessary reactor trip.

3.5.5 The cover plate on the rear of the safeguards panel in the control room shall not be removed without authorization from the Watch Supervisor.

3.5.6 When the reactor coolant system is above 350°F, the instrumentation requirements as stated in Table 3.5-5 shall be met.

Basis

Instrumentation has been provided to sense accident conditions and to initiate operation of the Reactor Protection System or the Engineered Safety Features[1,4].

Safety Injection System Actuation

Protection against a loss-of-coolant or steam break accident is brought about by automatic actuation of the Safety Injection System, which provides emergency cooling and reduction of reactivity.

The loss-of-coolant accident is characterized by depressurization of the Reactor Coolant System and rapid loss of reactor coolant to the containment. The Engineered Safety Features have been designed to sense the effects of the loss-of-coolant accident by detecting low pressure and generator signals actuating the SIS active phase.

The SIS active phase is also actuated by a high containment pressure signal (Hi-Level) brought about by loss of high enthalpy coolant to the containment. This actuation signal acts as a backup to the low pressurizer pressure signal actuation of the SIS and also adds diversity to protection against loss of coolant.

Signals are also provided to actuate the SIS upon sensing the effects of a steamline-break accident. Therefore, SIS actuation following a steamline break is designed to occur upon sensing high differential steam pressure between any two steam generators or upon sensing high steamline flow in coincidence with low reactor coolant average temperature or low steamline pressure.

The increase in the extraction of RCS heat following a steamline break results in reactor coolant temperature and pressure reduction. For this reason, protection against a steamline-break accident is also provided by low pressurizer pressure signals actuating safety injection.

Protection is also provided for a steamline break in the containment by actuation of SIS upon sensing high containment pressure.

SIS actuation injects highly borated fluid into the Reactor Coolant System in order to counter the reactivity insertion brought about by cooldown of the reactor coolant which occurs during a steamline-break accident.

Containment Spray

The Engineered Safety Features actuation system also initiates containment spray upon sensing a high containment pressure signal (Hi-Hi Level). The containment spray acts to reduce containment pressure in the event of a loss-of-coolant or steamline-break accident inside the containment. The spray cools the containment directly and limits the release of fission products by absorbing iodine should it be released to the containment.

Containment spray is designed to be actuated at a higher containment pressure (approximately 50% of design containment pressure) than the SIS (2.0 psig). Since spurious actuation of containment spray is to be avoided, it is automatically initiated only on coincidence of Hi-Hi Level containment pressure sensed by both sets of two-out-of-three containment pressure signals.

Steamline Isolation

Steamline isolation signals are initiated by the Engineered Safety Features closing all steamline stop valves. In the event of a steamline break, this action prevents continuous, uncontrolled steam release from more than one steam generator by isolating the steamlines on high containment pressure (Hi-Hi Level) or high steamline flow. Protection is afforded for breaks inside or outside the containment even when it is assumed that there is a single failure in the steamline isolation system.

Feedwater Line Isolation

The feedwater lines are isolated upon actuation of the Safety Injection System in order to prevent excessive cooldown of the reactor coolant system. This mitigates the effect of an accident such as steam break which in itself causes excessive coolant temperature cooldown.

Feedwater line isolation also reduces the consequences of a steamline break inside the containment by stopping the entry of feedwater.

Setting Limits

The Engineered Safety Features Actuation System instrumentation trip setpoints Specified in Table 3.5-1 are the nominal values at which the bistables may be set for each functional unit. A setpoint for an Engineered Safety Features Actuation System or interlock function is applicable to the process rack modules and is considered to be adjusted consistent with the nominal value when the "as left" value is within the band allowed for calibration accuracy. Sensor/Transmitters are considered to be adjusted consistent with the nominal value when the "as left" value(s) at the calibration point(s) is (are) within the band allowed for calibration accuracy. This band is defined by the calibration accuracy applied in both the conservative and non-conservative directions about the trip setpoint for process rack modules and calibration point(s) for sensor/transmitters as defined by plant calibration procedures and the plant setpoint study.

To accommodate the instrument drift assumed to occur between operational tests and the accuracy to which setpoints can be measured and calibrated, administrative limits for the setpoints have been determined. Operation with "as found" setpoints less conservative than the Trip Setpoint but within the administrative limit is acceptable since allowances have been made in the plant setpoint study to account for the applicable instrument uncertainties and the plant administrative process, including the administrative limit, verifying that the instrument performance complies with the plant setpoint study. Operation with "as found" setpoints less conservative than the administrative limit requires that further instrument operability evaluations be performed. This would include verification that the channel is capable of demonstrating operating performance within the design characteristics of the instruments through channel calibration, drift evaluations, instrument response characteristics, and other manufacturer recommended tests. Process rack modules or a sensor/transmitter found outside the "as left" band for calibration accuracy must be returned to within the band after the performance of each surveillance test.

1. The Hi Level containment pressure limit is set at 2.0 psig containment pressure. Initiation of Safety Injection protects against loss-of-coolant[2,4] or steamline-break[3,4] accidents as discussed in the safety analysis.

2. The Hi-Hi Level containment pressure limit is set at about 50% of design containment pressure. Initiation of Containment Spray and Steamline Isolation protects against large loss of coolant[2] or steamline-break accidents[3] as discussed in the safety analysis.

3. The pressurizer low-pressure limit is set substantially below system operating pressure limits. However, it is sufficiently high to protect against a loss-of-coolant accident as shown in the safety analysis[2].

4. The steamline high differential pressure limit is set well below the differential pressure expected in the event of a large steamline-break accident as shown in the safety analysis[3].

5. The high steamline flow limit is set at approximately 40% of the full steam flow at 0% to 20% load. Between 20% and 100% (full) load, the trip setpoint is ramped linearly with respect to first stage turbine pressure from 40% of the full steam flow to 110% of the full steam flow. These setpoints will initiate safety injection in the case of a large steamline-break accident. Coincident low T_{avg} setting limit for SIS and steamline isolation initiation is set below its hot shutdown value. The coincident steamline pressure setting limit is set below the full load operating pressure. The safety analyses show that these settings provide protection in the event of a large steamline break[3].

Instrument Operating Conditions

During plant operation, the complete instrumentation systems will normally be in service. Reactor safety is provided by the Reactor Protection System, which automatically initiates appropriate action to prevent exceeding established limits. Safety is not compromised, however, by continuing operation with certain instrumentation channels out of service since provisions were made for this in the plant design. This specification outlines limiting conditions for operation necessary to preserve the effectiveness of the Reactor Control and Protection System when any one or more of the channels is out of service.

Almost all reactor protection channels are supplied with sufficient redundancy to provide the capability for channel calibration and test at power. Exceptions are backup channels such as reactor coolant pump breakers. The removal of one trip channel on process control equipment is accomplished by placing that channel bistable in a tripped mode; e.g., a two-out-of-three circuit becomes a one-out-of-two circuit. A channel bistable may also be placed in a bypassed mode; e.g., a two-out-of-three circuit becomes a two-out-of-two circuit. The nuclear instrumentation system channels are not intentionally placed in a tripped mode since the test signal is superimposed on the normal detector signal to test at power. Testing of the NIS power range channel requires (1) bypassing the Dropped Rod protection from NIS for the channel being tested, and (2) defeating the ΔT protection channel set that is being fed from the NIS channel, and (3) defeating the power mismatch section of T_{avg} control channels when the appropriate NIS channel is being tested. However, the Rod Position system and remaining NIS channels still provide the dropped-rod protection. Testing does not trip the system unless a trip condition exists in a concurrent channel.

The Functional Units having risk informed AOTs are identified with either (1) or (2) in column 6 of Tables 3.5-2 through 3.5-4. Risk informed AOTs for analog channels is 72 hours and for logic channels is 24 hours. This is the maximum duration that a channel is permitted to be bypassed.

References

(1) UFSAR Section 7.2

(2) UFSAR Section 14.3

(3) UFSAR Section 14.2.5

(4) Safety Evaluation accompanying the Indian Point Unit No. 2 "Application for Amendment to Operating License," sworn to on May 29, 1979 by Mr. William J. Cahill, Jr. of Consolidated Edison.

Table 3.5-2

Reactor Trip Instrumentation Limiting Operating Conditions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
1.	Manual	2	1	1	0	Maintain hot shutdown	Same as Column 5
2.	Nuclear Flux Power Range	4	2	3	2	Maintain hot shutdown	(1)
2.a	Nuclear Flux Power Range	4	2	2	1	Maintain hot physics tests only	Same as Column 5
3.	Nuclear Flux Intermediate Range	2	1	1*	0	Maintain hot shutdown	Same as Column 5
4.	Nuclear Flux Source Range	2	1	1**	0	Maintain hot shutdown	Same as Column 5
5.	Overtemperature delta T	4	2	3	2	Maintain hot shutdown	(1)
6.	Overpower delta T	4	2	3	2	Maintain hot shutdown	(1)
7.	Low Pressurizer Pressure	4	2	3	2	Maintain hot shutdown	(1)

Table 3.5-2

Reactor Trip Instrumentation Limiting Operating Conditions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redundancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
8.	Hi Pressurizer Pressure	3	2	2	1	Maintain hot shutdown	(1)
9.	Pressurizer Hi Water Level	3	2	2	1	Maintain hot shutdown	(1)
10.	Low Flow Loop ≥ 75% F.P. Low Flow Two Loops 10-75% F.P.	3/loop 3/loop	2/loop (any loop) 2/loop (any two loops)	2/operable Loop 2/operable loop	1/operable loop 1/operable loop	Maintain hot shutdown	(1)
11.	Lo-Lo Steam Generator Water Level	3/loop	2/loop	2/loop	1/loop	Maintain hot shutdown	(1)
12.	Undervoltage 6.9 kV Bus	1/bus	2	3	2	Maintain hot shutdown	(1)
13.	Low frequency 6.9 kV Bus	1/bus	2	3	2	Maintain hot shutdown***	(1)
14.	Quadrant power tilt monitors	2	NA	1	0	Log individual upper and lower ion chamber currents once/shift and after load change > 10%	Same as Column 5

Table 3.5-2

Reactor Trip Instrumentation Limiting Operating Conditions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
15.	DELETED						
16.	Control Rod Protection****	3	2	2	1	During RCS cooldown, manually open reactor trip breakers prior to T_{cold} decreasing below 381°F. Maintain reactor trip breakers open during RCS cool-down when T_{cold} is less than 381°F.	Same as Column 5
17.	Turbine Trip ≥ 35% F.P. A. Low Auto Stop Oil Pressure	3	2	2	1	Maintain reactor power below 35% F.P.	(2)
18.	Reactor Trip Logic	2	1	2#	1#	Be in hot shutdown within the next six hours.	Same as Column 5

Table 3.5-2

Reactor Trip Instrumentation Limiting Operating Conditions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
19.	Reactor Trip Breakers	2	1	2#	1#	With either diverse trip feature inoperable, or the breaker incapable of tripping for any other reason, restore it to operable conditions or, be in hot shutdown within the next six hours and open both reactor trip breakers. The breaker shall not be bypassed except for the time required for performing maintenance and/or testing to restore it to operability.	Same as Column 5

Table 3.5-2

Reactor Trip Instrumentation Limiting Operating Conditions

F.P. = Rated Power

* If two of four power range channels are greater than 10% F.P., channels are not required.

** If one of two intermediate range channels is greater than 10^{-10} amps, channels are not required.

*** 2/4 trips all four reactor coolant pumps.

**** Required only when control rods are positioned in core locations containing LOPAR fuel.

A reactor trip breaker and/or associated logic channel may be bypassed for maintenance or surveillance testing for up to eight hours provided the redundant reactor trip breaker and/or associated logic channel is operable.

A reactor trip breaker and associated logic channel may be bypassed for corrective maintenance for up to 24 hours if corrective maintenance is required on the logic channel, provided the redundant reactor trip breaker and/or associated logic channel is operable.

(1) Restore all channels as required by column 1 to an OPERABLE status within 72 hours or place the inoperable channel in trip. Otherwise, maintain hot shutdown.

(2) Restore all channels as required by column 1 to an OPERABLE status within 72 hours or place the inoperable channel in trip. Otherwise, reduce reactor power below 35%.

Table 3.5-3

Instrumentation Operating Conditions for Engineered Safety Features

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redundancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
1	Safety Injection						
a.	Manual	2	1	1	0	Cold shutdown	Same as Column 5
b.	High Containment Pressure (Hi Level)	3	2	2	1	Cold shutdown	(1)
c.	High Differential Pressure Between Steam Lines	3/steam line	2/steam line	2/steam line	1/steam line	Cold shutdown	(1)
d.	Pressurizer Low Pressure*	3	2	2	1	Cold shutdown	(1)
e.	High Steam Flow in 2/4 Steam Lines Coincident	2/line	1/2 in any 2 lines	1/line in each of 3 lines	2	Cold shutdown	(1)
	With Low T_{avg} or Low Steam Line Pressure	4 T_{avg} Signals	2	3	2		
		4 Pressure Signals	2	3	2		

* Permissible bypass if reactor coolant pressure less than 2000 psig.

Table 3.5-3

Instrumentation Operating Conditions for Engineered Safety Features

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redundancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
2.	Containment Spray						
a.	Manual	2	1	1	0	Cold shutdown	Same as Column 5
b.	High Containment Pressure (Hi-Hi Level)	2 sets of 3	2 of 3 in each set	2 per set	1/set	Cold shutdown	(1)
3.	Loss Of Power						
a.	480V Emergency Bus Undervoltage (Loss of Voltage)	2/bus	1/bus	1/bus	0	Cold shutdown	Same as Column 5
b.	480V Emergency Bus Undervoltage (Degraded Voltage)	2/bus	2/bus	1/bus	0	Cold shutdown	Same as Column 5
4.	Auxiliary Feedwater						
a.	Steam Gen. Water Level (Low-Low)						
	i. Start Motor-Driven Pumps	3/stm gen.	2 in any stm gen.	2 chan. in each stm gen.	1	Reduce RCS temperature such that T < 350°F	(2)

Table 3.5-3

Instrumentation Operating Conditions for Engineered Safety Features

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
	ii. Start Turbine-Driven Pump	3/stm gen.	2/3 in each of two stm gen.	2 chan. in each stm gen.	1	T < 350°F	(2)
b.	S.I. Start Motor-Driven Pumps	(All safety injection initiating functions and requirements)					
c.	Station Blackout Start Motor-Driven and Turbine-Driven Pumps	2	1	1	0	T < 350°F	Same as Column 5
d.	Trip of Main Feedwater Pumps Start Motor-Driven Pumps	2	1	1	0	Hot shutdown	Same as column 5
5.	Overpressure Protection System (OPS)	3	2	2	1	Refer to Specification 3.1.A.4	Same as Column 5
6.	Engineered Safety Features (SI) Logic	2	1	2#	1#	Be in Hot shutdown within the next 6 hours	Same as column 5

Table 3.5-3

Instrumentation Operating Conditions for Engineered Safety Features

---

\# An Engineered Safety Feature (SI) logic channel may be bypassed for corrective maintenance for up to 24 hours or surveillance testing for up to eight hours provided the redundant logic channel is operable.

(1) Restore all channels as required by column 1 to an OPERABLE status within 72 hours or place the inoperable channel in trip. Otherwise, proceed to cold shutdown.

(2) Restore all channels as required by column 1 to an OPERABLE status within 72 hours or place the inoperable channel in trip. Otherwise, reduce T_{avg} to less than 350°F.

Table 3.5-4

Instrumentation Operating Conditions for Isolation Functions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
1.	Containment Isolation						
a.	Automatic Safety Injection (Phase A)	See Item No. 1 of Table 3.5-3				Cold shutdown	(1)
b.	Containment Pressure (Phase B)	See Item No. 2 of Table 3.5-3				Cold shutdown	(1)
c.	Manual						
	Phase A (one out of two)	2	1	1	0	Cold shutdown	Same as Column 5
	Phase B (one out of two)	2	1	1	0	Cold shutdown	Same as Column 5
2.	Steam Line Isolation						
a.	High Steam Flow in 2/4 Steam Lines Coincident with Low T_{avg} or Low Steam Line Pressure	See Item No. 1(e) of Table 3.5-3				Cold shutdown	(1)
b.	High Containment Pressure (Hi-Hi Level)	See Item No. 2(b) of Table 3.5-3				Cold shutdown	(1)
c.	Manual	1/loop	1/loop	1/loop	0	Cold shutdown	Same as Column 5

Table 3.5-4

Instrumentation Operating Conditions for Isolation Functions

No.	Functional Unit	1 No. of Channels	2 No. of Channels to Trip	3 Min. Operable Channels	4 Min. Degree of Redun-dancy	5 Operator Action if Conditions of Column 3 Cannot be Met	6 Operator Action if Conditions of Column 4 Cannot be Met
3.	Feedwater Line Isolation						
a.	Safety Injection	See Item No. 1 of Table 3.5-3					
4.	Containment Purge And Pressure Relief Isolation						
a.	Containment Radioactivity High (R-41/R-42)	2	1	*	0	*	*

* See Specification 3.1.F

(1) Restore all logic channels as required by column 1 to an OPERABLE status within 24 hours. Otherwise, proceed to cold shutdown.

Basis

The Safety Injection System and the Containment Spray System are principal plant safeguards that are normally inoperative during reactor operation. Complete systems tests cannot be performed when the reactor is operating because a safety injection signal causes reactor trip, main feedwater isolation and containment isolation, and a Containment Spray System test requires the system to be temporarily disabled. The method of assuring operability of these systems is, therefore, to combine systems tests to be performed during plant refueling shutdowns, with more frequent component tests, which can be performed during reactor operation.

The refueling systems tests demonstrate proper automatic operation of the Safety Injection and Containment Spray Systems. With the pumps blocked from starting, a test signal is applied to initiate automatic action and verification made that the components receive the safety injection signal in the proper sequence. The test demonstrates the operation of the valves, pump circuit breakers, and automatic circuitry(1).

During reactor operation, the instrumentation which is depended on to initiate safety injection and containment spray is generally checked daily and the initiating circuits are tested monthly (in accordance with Specification 4.1). The testing of the analog channel input is accomplished in the same manner as for the reactor protection system. The engineered safety features logic system is tested by means of test switches to simulate inputs from the analog channels. Test switches are also provided down stream of the master relay output contacts. The purpose of these test switches is to prevent actuation of engineered safety features equipment during testing. Verification that the logic is accomplished is indicated by the matrix test light and/or master relay operation.

Other systems that are also important to the emergency cooling function are the accumulators, the Component Cooling System, the Service Water System and the containment fan coolers. The accumulators are a passive safeguard. In accordance with Specification 4.1, the water volume and pressure in the accumulators are checked periodically. The other systems mentioned operate when the reactor is in operation and, by these means, are continuously monitored for satisfactory performance. Corrective (and not preventive) maintenance is permitted on a logic channel provided that the redundant channel is operable. For the RPS, 24 hours of such maintenance is permitted for the logic channel. This same 24 hour corrective maintenance period is permitted for the trip breaker if the logic channel requires maintenance at the same time.

For the four flow distribution valves (856 A, C, D and E), verification of the valve mechanical stop adjustments is performed periodically to provide assurance that the high head safety injection flow distribution is in accordance with flow values assumed in the core cooling analysis.