PROGRAM PLAN
for
PIPNG VERIFICATION PROGRAM
(THERMAL EXPANSION, STEADY STATE
VIBRATION, AND DYNAMIC EFFECTS)

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1. SCOPE OF PROGRAM

1.1 OBJECTIVE

Objective of the piping verification program is to assure the structural and functional integrity of piping systems important to safety.

1.2 GENERAL OVERVIEW OF PROGRAM

The piping verification program consists of three parts: thermal expansion, steady state vibration, and dynamic effects testing.

1.2.1 THERMAL EXPANSION

Selected major high energy lines with significant thermal differential (from ambient to greater than 200F) shall be incorporated into an instrumented program. The remainder of the lines (high and moderate energy) will be visually inspected by a qualified engineer.

1.2.2 STEADY STATE VIBRATION

All ASME Section III, Class 1, 2, and 3 piping and high energy steam and feedwater piping will be visually examined by a qualified engineer who will ascertain if detailed test data for the evaluation of the effects of flow induced vibration are required.

1.2.3 DYNAMIC EFFECTS

Dynamic effects testing shall be performed on those piping systems that are important to safety and are expected to undergo significant transient behavior due to: fast valve closure, pump starts and stops, steam hammer, and water hammer.

1.3 GENERAL METHOD OF DATA COLLECTION

The Data Collection System consists of primary sensors, signal conditioning, and a data-logger. Data acquisition will be performed with instruments of required accuracy and sensitivity as specified by three categories of tests - Thermal Expansion, Steady State Vibration, and Dynamic Effects. In each case, the data acquisition system will be designed for highly reliable and low-noise data collection.

1.3.1 THERMAL EXPANSION

During this test, pipe movements and temperatures are monitored by displacement transducers (Lanyards) and special surface temperature measuring thermocouples (J-type). These instruments are monitored by a test computer through four remote test units (multiplexers) (refer to Appendix B, figure B-1). Each multiplexer provides reference junctions for the necessary inputs from thermocouples and potentiometric or bridge completion circuits. The multiplexed signal is amplified, if necessary, and then transmitted to the computer where it will scan and digitize the inputs at a rate of 25 points/sec. The data are stored on magnetic tape for future reduction and printed out on a real-time basis in engineering units. Each pipe node is identified by a six digit alpha-numeric label, which will be printed out with the data. The system can monitor and log data on a periodic basis or upon operator request. Also, the system can average over a variable number of consecutive scans to obtain a raw data value.

Zero calibration (cold pipe location scan) is performed initially and stored as permanent record. Load calibration, checking drift in electronics, is performed on periodic basis or before each scan. This guarantees the accuracy of data irrespective of drift in electronics during the conduct of the test. The system prints out the time at which each scan begins and provides a discrete output for annuniciation whenever scanned data fall out of limits.

1.3.2 STEADY STATE VIBRATION

Piping is checked by visual means for steady state vibration during normal system operation. Where a quantitative measurement is required as a supplement to velocity, pressure, temperature, and density data needed for evaluation, temporary vibration monitoring instruments are used that will enable further analysis of frequency spectrum and amplitude relationships. These analyses are performed on recordings of these signals on a X-Y plotter system or by scanning them using an oscilloscope with band-pass filters.

1.3.3 DYNAMICS EFFECTS

These tests are performed to verify the adequacy of piping systems during transient conditions during normal plant operations and trips. The transients are monitored in terms of pressure fluctuations within pipes, pipe accelerations/displacements, and pipe support reactions or load-changes. Instruments required will be of high frequency response with necessary ranges covering the physical quantity being measured. Instruments, from sensor selection, its installation, cablings, and the recording instruments will be designed as a system meeting these criteria.

Pressure fluctuations are measured by gauges or piezoelectric transducers depending upon frequency response requirement. Transducers are installed flush with inside of pipe where possible. Pipe accelerations and displacements are measured by accelerometers and potentiometers attached to the pipe through lanyards. Support loads are measured by load-cells and/or bonded strain-gauges. Depending upon the number of points to be monitored

and their frequency response requirements, data are recorded on F.M. and/or oscillographic recorders, or monitored through high-speed multiplexer by the test computer. High-speed scans will be conducted at 20,000 samples/sec.-channel and stored on drum or mag. tape for subsequent data analysis.

1.4 ACCEPTANCE CRITERIA

1.4.1 BASIS-LINE AND POINT SELECTION CRITERIA

Line and point selection criteria are based on the criteria provided in: FSAR sections 3.6 and 3.9.2, the Basic Concepts for the Preoperational Test Program on Piping for Thermal Expansion, Steady State Vibration and Dynamic Effects; and section 3.9.2 of the U.S. Nuclear Regulatory Commission Standard Review Plan, Revision 1.

Points that are instrumented are selected on the basis that they will be representative and will provide meaningful and significant results.

1.4.2 ACCEPTANCE CRITERIA

1.4.2.1 Thermal Expansion

There shall be no unacceptable restraint of normal thermal motion. Where thermal deflection is measured, the deflections shall be compared to the thermal stress analysis of the piping system.

1.4.2.2 Steady State Vibration

Piping, components, restraints, and supports will be observed for steady state vibration. A qualified engineer will determine the need for, and details of, supplementary tests and, based on evaluation of long term effects on the structural integrity of the system, any corrective action to be recommended. Actions will be taken toward reducing the vibration and/or improving system structurally when necessary for its continued longterm reliability as a piping system.

1.4.2.3 Dynamic Effects

Instrumented dynamic effects testing will be performed on those piping systems where significant transient behavior is expected. Measured displacements, pressures, and temperatures will be compared to those used for design. A determination by a qualified engineer will be made of the effects and the need for any additional test data. The object is to determine if structural integrity is significantly degraded by the transients. Action will be taken toward mitigating the effects by operating procedure and/or design change when required for system reliability.

1.5 RESOLUTION OF DISCREPANCIES

When testing of a system reveals a condition that prevents the test procedure from being satisfied, this condition will be documented on a Test Exception Report (TER). All TERs will be routed to the NSSS Test Operations Supervisor who will assign the responsibility of resolving the TER. Test Exception Reports, documenting proposed design modification or design deficiencies, will be assigned to either SCE or BPC Engineering for review, approval, and implementation. Resolved TERs will be routed to the NSSS Test Operations Supervisor who will determine the extent of retesting necessary based upon the approved design requirements.

2. DISCUSSION

2.1 THERMAL EXPANSION PROGRAM

2.1.1 SCOPE OF TEST

The Thermal Expansion Program shall be implemented through two tests so that more conclusive data may be obtained. Test 1 shall be completed during the Hot Functional Test Phase, with all ASME Section III and high energy portions of the following systems to be monitored:

A. Main Steam

   1. Main Steam Bypass to Condenser

   2. Main Steam to Emergency Feedwater Pump Turbine Driver

   3. Steam Supply to Main Feedwater Pump Turbine Driver

   4. Main Steam from the Steam Generator to the Turbine Stop Valves

B. Shutdown Cooling System

C. Pressurizer Surge/Spray System Piping

D. Steam Generator Blowdown System

E. Letdown System Piping

F. Salt Water Cooling System

G. Component Cooling Water System

H. Diesel Fuel Oil Transfer System

I. Spent Fuel Pool Cooling System

J. Chilled Water System

K. Safety Injection System

L. Chemical and Volume Control System

M. Boric Acid Makeup System

N. Reactor Coolant System

O. Nuclear Sampling System

The thermal expansion test program will be performed in two separate tests: The first during pre-core hot functional testing, and the second during power ascention testing. For example, the main feedwater will not heat up appreciably during Test 1, therefore, it shall be monitored under Test 2, which shall be performed during the Power Ascension phase of testing. The Auxiliary Feedwater System shall also be monitored under Test 2. The Main and Auxiliary Feedwater Systems shall, however, be visually checked for acceptable expansion during Test 1, the Hot Functional testing.

2.1.2 METHOD OF PERFORMANCE

Primary objective of this test is to verify that, during the process of heating up and cooling down the plant, piping, subjected to various steady state temperature conditions, is free to expand and contract with no stress in excess of code allowables generated, from piping supports, hangers, stops, or the piping itself.

This portion of the program involves monitoring all applicable systems for piping expansion due to temperature changes of the metal itself. The monitoring shall be by instrumentation temporarily installed on the piping, installed measuring devices, as on all snubbers, and through visual inspection. The criteria for distinguishing between "instrumented" and "visual" monitoring have been established in the Acceptance Criteria under the Scope of Program of this plan. Specified temperature plateaus shall be attained with established hold periods for thermal transients to decay. All necessary data will then be obtained and recorded.

Detail of line and point designations covered under the Thermal Expansion Test are tabulated in Appendix A, Table 1, of this plan. All instrumented lines covered would include, but not be limited to, line number, location on the line (i.e. node), calculated deflections, and maximum allowable deflection tolerances.

All visually inspected lines covered would include, but not be limited to, line number and location of the line (i.e. elev.).

All snubbers covered would include, but not be limited to, recording the snubber number and the location of the snubber (i.e. node). Calculated cold and hot positions of the snubbers along with the allowable tolerances are tabulated in Appendix A, Table 2 of this plan.

All results of the test shall be evaluated and approved in accordance with Startup and Test Program, Test Instruction No. 4, "Review, Evaluation and Approval of Test Results". Further analyses shall be performed on unexpected results to ascertain the cause of the deviation. These exceptions shall be documented in accordance with Startup and Test Program, Test Instruction No. 4, "Review, Evaluation and Approval of Test Results", and if applicable, Test Instruction No. 28, "Startup Non-Conformance Reports".

If additional restraints are installed or piping rerouted which affects the high energy line break analysis, the NRC will be notified. The analysis that verifies system response is within acceptable limits will be on file.

2.2 STEADY STATE VIBRATION PROGRAM

2.2.1 SCOPE OF TEST

The Steady State Vibration Test, like the Thermal Expansion Test, shall be divided into two parts. Test 1 shall be performed during the Hot Functional Testing Phase and covers all ASME Section III portions, and high energy portions of the following systems:

A. Shutdown Cooling System

B. Steam Generator Blowdown System

C. Chemical and Volume Control System

D. Letdown System

E. Auxiliary Feedwater System

F. Salt Water Cooling System

G. Component Cooling System

H. Diesel Fuel Oil Transfer System

I. Spent Fuel Pool Cooling System

J. Chilled Water System

K. Safety Injection System

L. Boric Acid Makeup System

M. Nuclear Sampling System

N. Main Steam System

Test 2 shall be performed during the Power Ascension testing phase and shall include the high energy portions of the following systems not previously tested:

- Main Steam
- Main Feedwater

Inspection shall be performed at various power levels for the main steam and main feedwater systems to ascertain, qualitatively, flow-induced vibrations obtained during various modes of operation.

2.2.2 METHOD OF PERFORMANCE

The primary objective of Steady state vibration testing is to verify, through visual inspection, that vibrations in the piping system, induced by flow in the pipe and by equipment motion, do not produce significant vibration levels of the piping. Should significant system vibration be evidenced during the test, additional testing shall be pursued, where the maximum amplitude shall be measured by means of a portable vibration monitoring device.

The acceptance criteria are that the maximum measured amplitude shall not induce a stress in the piping system greater than one-half the endurance limit as defined in Section III of the ASME Boiler and Pressure Vessel Code, 1974.

Detail of the line designations for inspection shall be tabulated in Appendix A, Table 3 of this plan.

All results of the test shall be evaluated and approved in accordance with Startup and Test Program, Test Instruction No.4, "Review, Evaluation and Approval of Test Results", and all internal administrative procedures applicable to evaluation and approval of the steady state vibration test results. Test exceptions shall be documented in accordance with Startup and Test Program, Test Instruction No. 4, "Review, Evaluation and Approval of Test Results", and if applicable, Test Instruction No. 28, "Startup Non-Conformance Reports".

If additional restraints are installed as a result of the piping tests, the NRC will be notified. The analysis that verifies system response is within acceptable limits will be on file.

2.3 DYNAMIC EFFECTS PROGRAM

2.3.1 SCOPE OF TEST

The Dynamic Effects Program will be broken down into three test phases. Test 1 shall be performed during the Hot Functional Testing Phase and will include all systems to be tested under the scope of testing for dynamic effects except the Steam and Feedwater Systems and Steam Generator Feedwater Waterhammer Test.

Test 1 covers all ASME Section III portions of the following systems:

A. Safety Injection System

B. Chemical and Volume Control

C. Letdown System

D. Steam Generator Blowdown

E. Pressurizer Spray System

F. Shutdown Cooling System

G. Salt Water Cooling System

H. Component Cooling Water System

I. Diesel Fuel Oil Transfer System

J. Spent Fuel Pool Cooling System

K. Chilled Water System

L. Boric Acid Makeup System

M. Nuclear Plant Sampling System

N. Pressurizer Safety Valve Piping from the Pressurize to Safety Valves

Test 2, the Steam Generator Feedwater Waterhammer Test, shall be performed during Hot Functional testing to provide flexibility in initiating the test at various operating pressures.

In the past, successful testing of instrumented Auxiliary Feedwater Systems of similar design precluded the necessity for further instrumented testing; therefore, a visual examination shall be the only criteria basis for this test. Successful instrumented testing on Steam Generator Auxiliary Feedwater System has been performed at such places as:

- ARKANSAS NUCLEAR ONE - UNIT 2 (Modified J - Tube Type)
- FARLEY NUCLEAR PLANT - UNIT 1 (J - Tube Type)

Test 3, which will include the Steam and Feedwater Systems, shall be performed during Power Ascension testing phase, thereby obtaining more conclusive data.

The Dynamic Effects Program shall be implemented to verify that the piping and piping restraints, as tabulated in Appendix A, Table 4, will withstand dynamic effects due to transients such as pump starts and stops, and valve closures, with resultant loads within acceptable levels.

2.3.2 METHOD OF PERFORMANCE

Monitoring of specified lines and points shall be by instrumentation, temporarily installed on the piping, and through visual inspection. Conditions, as outlined below, shall be established, instrumentation (i.e., recorders) actuated, and the transient initiated. Conditions established for the transients would include:

A. Hot Functional Testing

1. Start and stop of the charging pumps - during conditions of both low and high pressure within the reactor coolant system.

2. Letdown System - opening and closing of valves while the Reactor Coolant System is in operation.

3. Opening and closing of the pressurizer spray control valves under maximum flow condition.

4. Shutdown Cooling System - opening of the isolation valves and operation of the LPSI pumps with the system aligned for shutdown cooling.

5. Steam Generator Blowdown - opening and closing of the isolation valves while the steam generator is at normal operating conditions.

6. Operation of the turbine dump bypass valves during low pressure (as a precursor) and maximum operating pressure conditions.

7. Safety Injection - during start, full operation, and shutdown of the HPSI and LPSI pumps.

8. Steam Generator Waterhammer - lowering steam generator water level and initiation of auxiliary feedwater under simulated operating conditions. Will be performed at pre-core Hot Functional testing, and include the pressure/temperature conditions for zero and full power.

9. Starting and stopping:

   a. Boric Acid Pumps

   b. Salt Water Cooling Pumps

   c. Component Cooling Water Pumps

   d. Chilled Water Pumps

   e. Diesel Fuel Oil Transfer Pumps

   f. Containment Spray Pumps (Placed on Recirculation)

   g. HPSI/LPSI Pumps

10. Initiation of Fuel Pool Cooling System.

B. Power Ascension Testing

1. Main steam flow transients
2. Main F.W. flow transients

} Will be performed at 50 and 100 percent power level.

All results of the testing shall be evaluated and approved in accordance with Startup and Test Program, Test Instruction No.4, "Review, Evaluation and Approval of Test Results". Exceptions shall be documented in accordance with Startup and Test Program Manual, Test Instruction No. 4, "Review, Evaluation and Approval of Test Results" and, if applicable, Test Instruction No. 28, "Startup Non-Conformance Reports".

If additional restraints are installed or piping rerouted as a result of the preoperational piping test, the NRC will be notified. The analysis that verifies system response is within acceptable limits will be on file.

3. CONDUCT OF TESTING

Conduct of all tests developed for the Piping Verification Program shall be administered and functionally controlled, under the direct supervision of individuals qualified in stress engineering, in accordance with the scope of testing outlined in the Startup and Test Program Manual (Test Instructions) and as specified in Chapter 14 of the FSAR.

Changes to the Piping Verification Program tests shall be made as necessary to improve the tests or to incorporate modifications for existing technical or regulatory requirements that affect testing. Change approval shall be in accordance with the applicable Test Instructions.

3.1 QUALIFICATIONS OF PERSONNEL

Personnel, as listed in Paragraph 14.2.2.3 of the FSAR, involved in the conduct of testing under the Piping Verification Program shall be qualified to perform, review, and manage the test program in accordance with ANSI N45.2.6-1973 as interpreted in Paragraph 14.2.7.2.3 of the FSAR. Individual qualifications shall also be forwarded, in resume form, to SCE Management for review and approval.

3.2 TRAINING

Indoctrination or special training and certification required for personnel involved in the testing shall be in accordance with the Startup and Test Program, Test Instruction No. 26, "Startup Training".

3.3 REPORTABILITY

All results and analyses of the program testing shall be reviewed, evaluated, and approved in accordance with Startup and Test Program Test Instruction No. 4, "Review, Evaluation and Approval of Test Results". All documentation shall be maintained in accordance with Startup and Test Program, Test Instruction No. 5, "Document Control".

Test Procedure exceptions shall be documented in accordance with Startup and Test Program, Test Instruction No. 4, "Review, Evaluation and Approval of Test Results", and if applicable, Test Instruction No. 28, "Startup Non-conformance Reports".

Resolution of any discrepancies shall be as outlined in Section 1, Subsection 1.5 of this plan.

ATTACHMENTS

1. Appendix A - Line and Point Designations

   Table 1 - Thermal Expansion Line and Point Designations

   Table 2 - Thermal Expansion Calculated Hot and Cold Snubber Positions

   Table 3 - Line Designation List for Steady State Vibrations

   Table 4 - Line Designation for Dynamic Effects Testing

2. Appendix B - Data Acquisition System Block Diagram, Figure 1.

Note: Tables 1, 3, and 4 will be submitted by approximately November 1979. Table 2 will be submitted by approximately May 1980.

APPENDIX A

Line and Point Designations

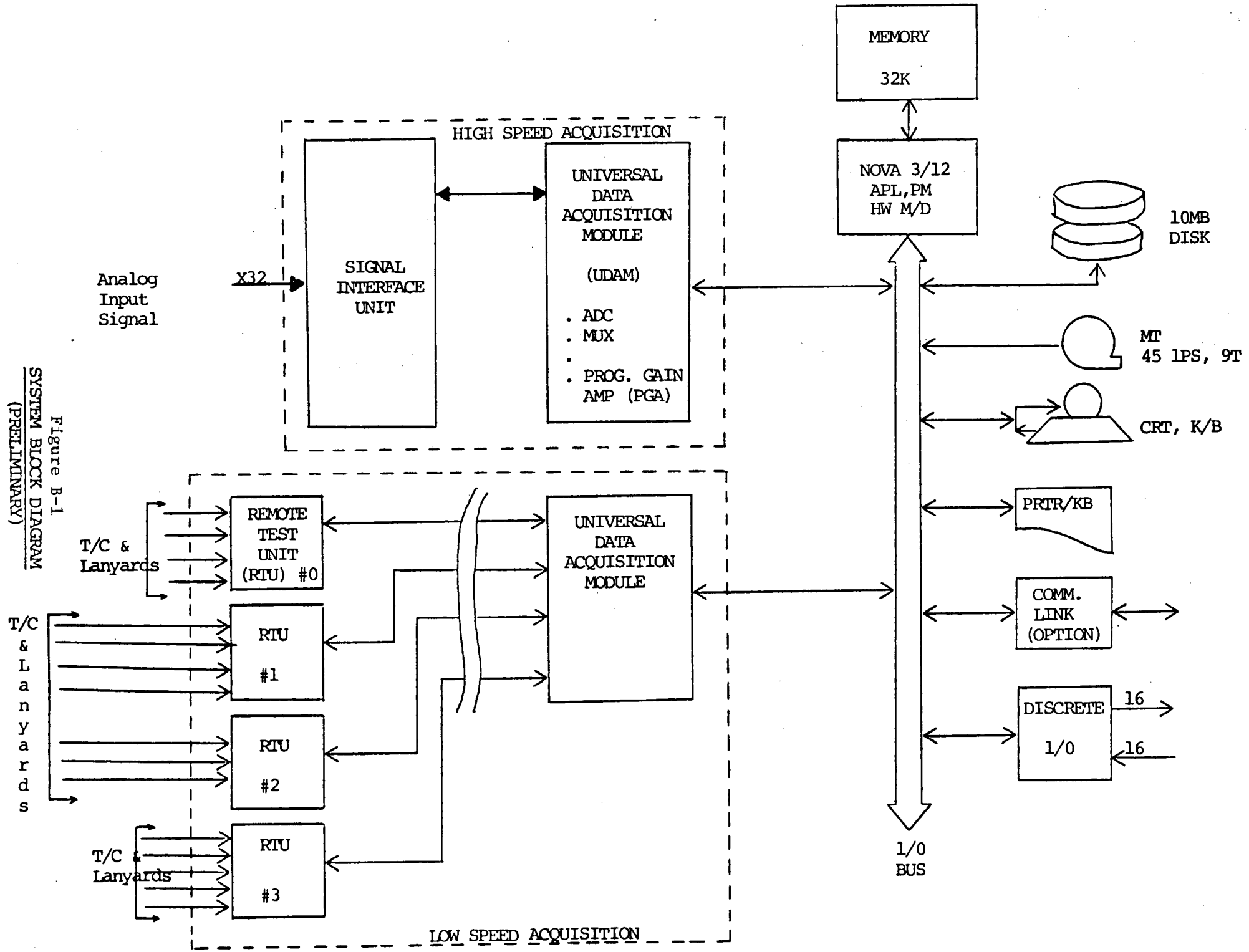

Figure B-1
SYSTEM BLOCK DIAGRAM
(PRELIMINARY)