VL 16362

AMPACITY DERATING OF FIRE PROTECTED CABLES

Project No. 12340-94583,95165-95168,95246

ELECTRICAL TEST TO DETERMINE THE AMPACITY DERATING OF A PROTECTIVE ENVELOPE FOR CLASS 1E ELECTRICAL CIRCUITS

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assembly) or the instrumented cable was removed from the clad conduit and inserted into a similarly constructed, bare conduit.

THERMOCOUPLES

Temperatures on the cable conductors within the conduit and air drop assemblies were measured with Type T, 24 gauge, Copper-Constantan electrically welded thermocouples formed from Copper and Constantan wires of "special limits of error (±0.5°C)," and covered with Teflon FEP® insulation. Temperatures on the cable conductors within the cable tray assembly were measured with Type K, 24 gauge, Chromel-Alumel electrically welded thermocouples formed from Chromel and Alumel wires of "special limits of error (±1.1°C)," and covered with braided fiberglass insulation. All thermocouple wire was calibrated to ±0.5°C.

DATA ACQUISITION SYSTEM

The outputs of the test article thermocouples and room control thermocouples were monitored by a data acquisition system consisting of a John Fluke Mfg. Co. Model HELIOS I 2289A Computer Front End, and an Apple Computer Co. Macintosh Classic microcomputer. The Computer Front End was connected to the RS422 Serial Interface Port of the Macintosh. The computer was programmed in Microsoft BASIC to command the HELIOS unit to sample the data input lines, receive and convert data into a digital format, and to manipulate the data for display on screen, the hard copy printout, and saving to hard disk. The computer program determined, and displayed, the average temperatures at each of the three positions on each test article. The rate of change of temperature for the average of the thermocouples located in the center portion of the test article was then calculated. All individual data points and calculated values were saved on hard disk at one minute intervals. A record of individual location temperatures, maximum temperatures and rates of change of temperatures was printed at five minute intervals. All test data is presented in Appendix F: TEST DATA.

CURRENT CONTROL SYSTEM

The current flow through the test articles was regulated using process control type devices. The available voltage for any test control circuit was 208 Vac single phase. A Silicon Controlled Rectifier (SCR) device (Halmar Robicon Group Model No. 140P-FK2-CL) was used to vary the voltage available to the primary side of a step-down transformer between 0 Vac and 208 Vac in proportion to a 4-20 mA control input. The test article was connected to the secondary side of the step-down transformer. A proportional-integral-derivative process controller (Honeywell Universal Digital Controller Model No. UDC 3002-0-000-1-00-XXXX) was responsible for generating the 4-20 mA signal fed to the SCR device, based on a voltage feedback loop. A current transformer (Flex-Core Model No. 58-151, 150:5

TEST ASSEMBLIES

TEST ITEMS (GENERAL)

The conduit materials used in the test were provided by Texas Utilities , and are representative of those installed at CPSES.

Cable tray materials used in this test were purchased by Omega Point Laboratories from B-Line Systems, Inc. (Cat. No. 248P0924144). The following table provides pertinent data on the cable tray material used:

ATTRIBUTE	DIMENSION
Side rail thickness	0.048 in.
Rung thickness	18 GA
Rung spacing	9 in. o.c.
Rung dimensions	1-5/8 in. w x 13/16 in. h x 3/8 in. leg

Cable tray straight sections consisted of ASTM A446, GR A, pre-galvanized steel, ASTM A525.

All test items (with the exception of the cable tray assembly) were constructed from materials extracted from TU Electric's Comanche Peak Steam Electric Station stock material storage areas in accordance with existing site procedures.

Electrical cables used in this test (with the exception of the cable tray assembly) consisted of cables supplied by TU Electric and taken from CPSES inventory. Cables used in these tests were as follows:

CABLE TYPE	CABLE FUNCTION	DESCRIPTION	DIAMETER (in.)	CROSS-SECTIONAL AREA (in^2)
W-020	Power	3C/#6 AWG 600v.	0.980	0.754
W-026	Power	3C/#10 AWG 600v.	0.617	0.299
W-008	Power	1/C 750 kCMil. 600v.	1.290	1.307
XHHW	Power	3C/#6 AWG 600v.	0.750	0.442

The diameters and cross-sectional areas listed herein represent the Laboratory's average of ten measurements of each cable type.

Scheme #AC-4

The assembly consisted of a 2 in. conduit through which was pulled a single three conductor cable (W-020, 3C/#6 AWG, 600V). The total cable length used for this test item was 60 ft. The three separate conductors within the cable were connected into a single series circuit. The current source was then connected to the two free cable ends. Two conduits were prepared for testing; one clad and one bare - for baseline testing.

Scheme #AC-5

The assembly consisted of a 5 in. conduit through which was pulled four separate single conductor cables (W-008, 1/C 750 kCMil, 600V). The total cable length used for this test item was 88 ft. The four separate conductors were connected into a single series circuit. The current source was then connected to the two free cable ends. Two conduits were prepared for testing; one clad and one bare - for baseline testing.

Scheme #AA 1-1

The assembly consisted of a single three conductor cable (W-020, 3C/#6 AWG, 600V) representing an air drop assembly. The total cable length used for this test item was 60 ft. The three separate conductors within the cable were connected into a single series circuit. The current source was then connected to the two free cable ends. The cable was clad and allowed to cure. The material was then removed to perform the baseline testing.

Scheme #AA 4-2

The assembly consisted of three separate single conductor cables (W-008, 1/C 750 kCMil, 600V) representing an air drop assembly. The total cable length used for this test item was 88 ft. The three separate conductors were connected into a single series circuit. The current source was then connected to the two free cable ends. The cable was clad and allowed to cure. The material was then removed to perform the baseline testing.

Scheme #AT-1

The assembly consisted of a 24 in. wide x 4 in. deep cable tray assembly into which was laid 126 passes of single three conductor cable (3C/#6 AWG, TC XHHW CDRS, 600 Volt). The total cable length used for this test item was 1720 ft. The three separate conductors within the cable were connected into a single series circuit and the current source was then connected to the two free cable ends. The

24 IN. CABLE TRAY

CABLE TYPE	NUMBER PRESENT	CROSS-SECTIONAL AREA (in^2)	% OF TOTAL AREA
3C/#6	126	55.665	77.31

THERMOCOUPLE PLACEMENT

24 gauge, Type T, Copper-Constantan electrically welded thermocouples (Special Limits of Error: ±0.5°C, purchased with lot traceability and calibration certifications) were attached in nine places within each conduit or air drop assembly, by slicing through the outer jacket of the cable (down to bare conductor) and placing the thermojunction in direct contact with the top surface of the cable conductor and covering the slit with a double wrap of glass fiber reinforced electrical tape (Glass Cloth Electrical Tape, Class "B" Insulation, 1/2 in. wide, 3M Corporation, Item No. 27) for a minimum distance of 3-1/2 inches. Thirty-nine 24 gauge, Type K, Chromel-Alumel electrically welded thermocouples (Special Limits of Error: ±1.1°C, purchased with lot traceability) were similarly secured to the cables within the cable tray assembly. A representative sample of the thermocouple wire used in the cable tray test article was calibrated after the test procedure.

One thermocouple was located on each of the three conductors in each system (except the cable tray and 5 in. conduit having four conductors) at the mid-point of the assembly, and at both ends of the assembly (36 in. left and right of mid-point). The 5 in. conduit having four conductors was similarly instrumented, however, the fourth conductor had no thermocouples installed. The cable tray assembly was instrumented with a total of thirty-nine thermocouples (thirteen located at the mid-point of the cable tray, thirteen located 36 in. to the left and 36 in. to the right of mid-point) located within the second and third layer of cables.

THERMO-LAG® INSTALLATION HIGHLIGHTS

Thermo-Lag® materials were installed in accordance with the instructions contained in the CPSES Site Procedures referenced in Test Plan, Rev. 4. Short abstracts of the installation are included herein to clarify specific details.

Thermo-Lag® 330-1 Pre-Shaped Conduit Sections (1/2 in. nom. thickness)

This material was used to construct the 3/4 in., 2 in. and 5 in. diameter raceway design protective envelopes.

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During construction of the cable tray protective envelope, several areas of the envelope were reinforced with combinations of stainless steel wire, Thermo-Lag® 330-1 Trowel Grade Material and Thermo-Lag® 330-69 Stress Skin which was secured with staples. The areas reinforced included butt joints between panels on the bottom surface of the envelope and the longitudinal seams where the top and bottom panels overlap panel pieces installed at the tray side rails.

The butt joints between panels on the bottom surface were "stitched" with stainless steel tie wires on 5 in. centers. A thin layer of 330-1 Trowel Grade Material (approximately 3/16 in. thick) was next applied extending 5 in. on each side of the butt joints. Stress skin was cut and wrapped circumferentially around the envelope to overlap the butt joints by 5 in. on each side. The stress skin was worked into the trowel grade layer and secured in place with staples and stainless steel tie wire. A skim coat of 330-1 Trowel Grade Material, approximately 1/16 in. thick, was then applied over the stress skin and the tie wires.

To reinforce the longitudinal seams at the side rails, a 3/16 in. thick layer of 330-1 Trowel Grade Material was applied over the pane's installed at the side rails and extending 5 in. towards the middle of the tray and both the top and bottom surfaces. Stress skin was cut and formed into a squared, U-shaped configuration which was placed over the sides and onto the top and bottom surfaces for a 5 in. distance. The stress skin was worked into the trowel grade layer and secured in place with staples and stainless steel tie wire. A skim coat of 330-1 Trowel Grade Material, approximately 1/16 in. thick, was then applied over the stress skin and tie wires.

Finally, Thermo-Lag® 350 Topcoat was applied over all areas where 330-1 Trowel Grade Material had been applied following a 72 hour (minimum) cure time.

Each cable air drop assembly was clad with three complete wraps of Thermo-Lag® 330-660 Flexi-Blanket Material. An overlap of 2 in. - 4 in. was maintained for each wrap. The overlap area of each wrap was pre-caulked with Thermo-Lag® 330-660 Trowel Grade Material and secured with stainless steel bands spaced on 6 in. centers. The overlap areas were positioned 180° from one another.

TEST RESULTS

The completed test specimens were placed in the Laboratory's test enclosure and the thermocouples connected to the data acquisition system and their outputs verified. The tests were conducted from March 2, 1993, to March 14, 1993, by Herbert W. Stansberry II, project manager, with the following persons present at various times:

TEST ITEM	EQU. VOLTAGE (VOLTS)	EQU. CURRENT (AMPS)	EQU. TEMP (°C)	ROOM TEMP (°C)	CORRECTED CURRENT (AMPS)	PERCENT DERATING
750 kCMil in Air Drop (base)	5.21	785	89.5	40.2	790	31.8
750 kCMil in Air Drop (clad)	3.62	540	90.0	39.9	539	
4/C 750 kCMil in 5" Conduit (base)	2.19	567	89.4	40.2	571	10.7
4/C 750 kCMil in 5" Conduit (clad)	2.08	509	90.0	40.2	510	

The equilibrium current values are single-point measurements performed after the system was at equilibrium and the change in current was very low. The Equ. Temp (equilibrium conductor temperature at the hottest location), and the Room Temp are reported as 60 minute average values. The Corrected Current values are those calculated in accordance with P 848/D12 IEEE Standard Procedure for the Determination of the Ampacity Derating of Fire Protected Cables*, which corrects these current values to a room temperature of 40°C and a conductor temperature of 90°C.

$$* \quad I' = I\sqrt{\frac{(Tc' - Ta') \times (\alpha + Tc)}{(Tc - Ta) \times (\alpha + Tc')}}$$

where

I	test current at equilibrium, amperes	
Tc	hottest conductor temperature at center at equilibrium, °C	
Ta	measured enclosure ambient temperature, °C	
I'	normalized current, amperes	
Tc'	normalized conductor temperature	= 90°C
Ta'	normalized ambient temperature	= 40°C
α	234.5 for copper	

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ENCLOSURE 2

AMPACITY SAMPLE CALCULATION

ENCLOSURE 2

AMPACITY SAMPLE CALCULATION

1.1 CRITERIA

1.1.1 Conductor temperature not to exceed insulation rating of 90°C. [References 4.8 and 4.9]

1.1.1.1 Conductors shall be capable of carrying 125 percent of rated full load current continuously. Ampacities will be acceptable if the ratio of calculated ampacity to loading amperes is greater than or equal to 1.25. [Reference 4.11]

1.1.1.2 Where 1.1.1.1 is not met, loading will be acceptable if it can be shown that the conductor temperature does not exceed 90°C in every tray section the cable passes through, including effects of derating. Configuration will be acceptable if margin is greater than or equal to the derating factor for each tray section.

1.2 ASSUMPTIONS

1.2.1 600V insulation for low voltage cable, 8KV for 5KV, and 15KV for 13.8KV cable.

1.2.2 For the conventional method, in accordance with References 4.2 and 4.6, allowable heat intensities are calculated as if all cables in tray are fully loaded. Where control cables are mixed with low-voltage power cables, the power cable is derated as if all cables in the tray were power cable. [Reference 4.1]

1.2.3 Heat dissipation through the sides of the tray is conservatively neglected.

1.2.4 For the unwrapped/uncovered tray, the cooling effect of possible air flow through the cable mass is conservatively neglected.

1.2.5 Loads which operate only for short time periods, such as motor operated valves, dampers, and alarm circuits, are not included when calculating heat dissipation in the Diversity Method due to their intermittent nature.

1.2.6. For the Diversity Method, all non-intermittent loads are conservatively considered to operate simultaneously.

1.2.7 In describing various features of the Class 1E systems, the PVNGS UFSAR previously stated in 8.3.1.1.3.2:

> "All 5kV and 600 volt cables have been designed for operation as follows:"... "B. The Conductor is intended for use at normal conductor temperature not exceeding 90°C with an ambient temperature of 60°C..."

However, the UFSAR is being amended to modify this requirement (SARCN-3637). For this calculation, it is assumed that the ambient temperature for both Class 1E and Non-Class 1E cables is as given in References 4.10 and 4.12. These values represent the worst case normal / abnormal temperatures for rooms / buildings in the plant. For all rooms with maximum temperatures of 104°F (40°C) or lower, the ambient temperature is conservatively assumed to be 40°C. While Reference 4.10 shows the cable spreading rooms at 122°F (50°C), calculation 13MCHJ003 shows these areas not exceeding 104°F (40°C); ambient tem-

perature for these rooms is assumed to be 40°C as well. The following areas are assumed to have ambient temperatures greater than 40°C:

1.2.7.1 Turbine Building 50°C [Reference 4.10]

1.2.7.2 Diesel Generator Control Room 50°C [Reference 4.10]

1.2.7.3 Containment Building 48.9°C [Reference 4.12]

1.2.8 Reference 4.2 limits the ampacities of cables in randomly filled trays to 80% of the free air values listed in Reference 4.3. Since there are no tables for 600V cable in Reference 4.3, the 1KV ampacities are used.

1.2.9 As stated in Reference 4.2, the depth of tray fill is calculated using the square of the cable diameter. Examination of the ampacity tables in Reference 4.2 shows that the diameter squared is also used as the cable cross sectional area to calculate ampacity.

1.2.10 As stipulated in Reference 4.2, the ac resistance of conductors for cables in randomly filled trays includes skin effect, but not proximity effect. These resistances are based on Tables 1-3, 1-4, and 1-5 of OKONITE CABLES BULLETIN EHB-81 (attached)

1.2.11 Final cable ampacities include the effects of routing conditions. Tray configurations including covers, fire protective wrap, fire stops, etc. introduce derating factors which are applied to the nominal ampacity of the cable. Since all information on tray as-built configurations is not available at this time, the derating factor for covered trays is conservatively assumed and applied to all cables in trays without Thermolag applied, whether those trays were covered or not. Cables in wrapped tray are derated based on current industry testing. Cables with loading amperes exceeding this derated ampacity should be considered on a case by case basis. Derating for fire stops is applied to trays confirmed not to have covers.

1.2.11.1 Worst case derating for trays with covers is 74% of the uncovered value. [Reference 4.1, Table 12.3].

1.2.11.2 Worst case derating for trays traversing fire stops is 85% of the open tray value [Reference 4.1, Table 12.4]

1.2.11.3 Worst case 1 hour and 3 hour Thermo-Lag 330 derating from NRC Generic Letter 92-08 is 1 -.374 = 0.626, or 62.6% and 1 -0.389 =.611, or 61.1% of the unwrapped value respectively [based on testing; Underwriters Laboratories, Incorporated (UL) test provided worst case 3 hour and Southwest Research Institute (SWRI) provided worst case 1 hour derating]. The UL 0.389 value is assumed to be applicable to the case of trays with both cover and fire wrap (Thermolag) as well.

1.2.11.4 Subsequent to the initial run of calculation 01-EC-ZA-300, the applicability of the Texas Utility Thermolag testing was established by APS. Comanche Peak "Ampacity Derating of fire protected Cables" (project 12340-94583 et al) demonstrated an ~32% Derating Factor as being applicable to cable trays. Based upon the PVNGS evaluation, the test specimen (scheme AT-1) is considered functionally identical in

terms of materials, assembly configuration and relative material thicknesses, and constitute an approximate representation of the PVNGS as-built trays. However, this reduced derating factor has not been used in the ongoing Plant ampacity assessment.

1.2.12 Loading amperes for 13.8KV/480V transformer feeder cables are conservatively based on transformer ratings. The largest transformer is 1500KVA, therefore the loading amperes are assumed to be: $1500KVA/13.8KV/\sqrt{3} = 63Amperes.$

1.2.13 Loading amperes for Motor Control Centers are assumed to be 183 amperes per cable for those fed by parallel 350KCMIL cables. Loading for those fed by a single 500KCMIL cable is assumed to be 249 amperes. Where loading is shown to be greater in calculation 01-EC-MA-221, AC Distribution, loading amperes are taken as the highest full power value given.

1.2.14 Cable impedance is conservatively neglected when calculating loading amperes for 480V and above power circuits.

1.2.15 Low current (i.e. less than 3 amps) control or instrument circuits, operated continuously have an insignificant contribution to the heat loading of a given tray or raceway section.

1.3 Electrical General Design Criteria, Part II, section 4.3.3.2 stated that effects of heat retention capabilities shall be accounted for in cable sizing criteria and verified by watts/feet calculation method. This section has been revised to reflect the Industry Standard methodology currently being used to revalidate the ampacity of cables at PVNGS. In a letter dated December 7, 1994 to Mr. William L. Stewart, the Nuclear Regulatory Commission presented several reasons this method is unacceptable. As part of the Calculation Reverification Project, ampacities have been calculated using the methods in ICEA P-54-440 (NEMA WC 51-86) and using actual tray fills for trays filled to a depth greater than 1.15". This method is consistent with UFSAR section 8.3.1.4.3. Under CRDR 9-5-0479, Action 7, the Electrical General Design Criteria, Part II has been updated to reflect the methodology presented in this calculation.

2. INPUT DATA

2.1 The majority of this calculation is performed electronically. To allow electronic access, the input data is stored in databases and ASCII text files. The Qualified Data (QD) and Non-Qualified Data (NQD) input files used in this calculation.

2.2 Power Cables

2.2.1 Cable lengths and codes are taken from PDMS and are given in "Cable Data" QD files. In calculating loading amperes, cable impedances are given in Ohms/1000 ft. based on 75° C in "Cable Codes, Impedances" QD files.

2.2.2 Cable sizes, diameters, and number of conductors are taken from PDMS and given by cable code in QD file CBLCODES.DBF.

2.2.3 AC resistances including skin effect, but not proximity effect are given for each cable code in Ohms/1000 ft. and are based on 75° C in QD file RACODES.DBF.

2.2.4 Power cables in trays are identified by an electronic comparison of PDMS listing of all cables in trays to Network Configuration Model files. Additional cables were identified during resolution of CRDR 9-5-0479.

2.2.5 Circuit configurations are based on single-line drawings, elementary drawings, and PDMS circuit and raceway schedule.

2.2.6 Power cable loading amperes are based on attached loads. For power cable identified in Network Configuration Model files, load data is given in "Loading Characteristics" QD files.

2.3 Free air ampacities and ampacities for cables installed with maintained spacing are taken from Reference 4.3 and are shown in Table 2.1 Free Air Ampacities

2.4 Ampacities for cables in randomly filled trays are calculated for specific cable and tray conditions using the methods and data given in References 4.2 and 4.6.

2.5 Tray fills and routing conditions (e.g. fire stop, uncovered, covered, fire protective wrap) are taken from PDMS and are shown in QD file U1TRAYS.DBF. Walk down information was used to identify additional trays with fire protective wrap. This information is documented in Study 13CSA12 and is being incorporated into PDMS.

SAMPLE CALCULATION

Table 2.1: Free Air Ampacities

	1KV Cables(40°C)		5KV Cables (40°C)				15KV Cables (40°C)			
	Ampacity (Amps)		1 Conductor		3 Conductor		1 Conductor		3 Conductor	
Size	1 Conductor	3 Conductor	Amps	Delta TD	Amps	Delta TD	Amps	Delta TD	Amps	Delta TD
8	83	59	------	--------	------	--------	------	--------	------	--------
6	109	79	112	0.11	93	0.18	------	--------	------	--------
4	145	104	148	0.12	122	0.19	------	--------	------	--------
2	192	138	195	0.13	159	0.21	195	0.32	164	0.49
1	223	161	225	0.13	184	0.22	225	0.33	187	0.52
1/0	258	186	260	0.14	211	0.23	259	0.34	215	0.54
2/0	298	215	299	0.14	243	0.24	298	0.35	246	0.55
3/0	345	249	345	0.15	279	0.25	343	0.36	283	0.57
4/0	400	287	400	0.15	321	0.26	397	0.37	325	0.59
250	445	320	444	0.16	355	0.26	440	0.38	359	0.61
350	552	394	549	0.16	435	0.28	543	0.40	438	0.64
500	695	487	688	0.17	536	0.29	678	0.41	536	0.68
750	898	615	889	0.18	668	0.31	872	0.43	669	0.71
1000	--------	--------	1061	0.19	768	0.32	1040	0.45	770	0.74
1250	--------	--------	1211	0.18	------	--------	1185	0.44	------	--------
1500	--------	--------	1347	0.18	------	--------	1313	0.45	------	--------
1750	--------	--------	1470	0.19	------	--------	1430	0.46	------	--------
2000	--------	--------	1574	0.19	------	--------	1535	0.46	------	--------

Ampacities for single and three conductor copper concentric stranded rubber insulated cable in air as given in AIEE S-135-1-62/IPCEA P-46-426, Pages 215 and 309.

3. CALCULATION AND RESULTS

3.1 METHODOLOGY

3.1.1 General

The life of cable insulation is a function of temperature. When cables carry current they generate heat. Ampacities are established to ensure the life expectancy of the cable insulation is within anticipated or designed limits. This is accomplished by establishing upper current bounds to ensure the operating temperature of the conductor does not exceed the continuous 40-year temperature rating of the insulation, in this case 90°C.

UFSAR Section 8.3.1.4.3 adopts the use of Reference 4.2 for sizing cables at PVNGS, as outlined in Section 3.1.2. The method described in Section 3.1.3 is used to justify apparent overloading of cables that do not meet the sizing criteria specified in the UFSAR. This method assures that portion of the cable routed through a specific tray section will not overheat. To assure loading is acceptable, each affected cable tray (each tray in which the subject cable does not meet the sizing criteria specified in the UFSAR) must be analyzed individually.

3.1.2 Conventional Method

IEEE Standard 666: *IEEE Design Guide for Electric Power Service Systems for Generating Stations* [Reference 4.1] provides guidance in calculating ampacities for various routing conditions. When cables become tightly packed, as in randomly filled trays, there is little air flow through the bundle, and heat cannot be carried out of the bundle by natural air flow. Due to this loss of heat transfer, conductors will reach rated temperature with less current flow than for cables in free air. IEEE Std 666 directs that for cable in randomly filled tray, allowable continuous ampacities be calculated from the methods presented by Stolpe [Reference 4.6] and NEMA WC51/ICEA P-54-440 [Reference 4.2]. Ampacities for cable installed in tray with maintained spacing are obtained from the methods presented in IEEE S-135 [Reference 4.3].

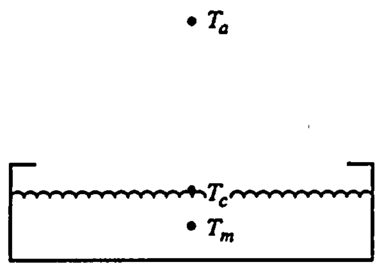
When power cable passes through tray with different thermal insulating characteristics, e.g. trays with covers, fire wrap, etc., their ability to transfer heat is further reduced. Under these conditions, conductors will reach rated temperatures with even lower loading currents, and ampacities must be further derated to compensate for this effect. Applicable derating factors are taken from IEEE Std 666 and Industry testing [Assumption 1.2.11].

In general, an electronic search of PDMS data is performed to identify all power cables. Cable loading amperes are calculated for each of these based on load characteristics. Ampacities are calculated based on cable data, tray fill, conductor operating temperature and ambient temperature. Routing conditions are examined, and the appropriate derating factor applied. Ratios of calculated ampacities and derated ampacities to loading amperes meeting Criteria 1.1.1.1 are acceptable.

....

3.1.3 Diversity Method

Conventional sizing methodology for cables in cable trays was developed by J. Stolpe as described in Section 3.1.2 above. The Stolpe method treats the cable mass as a rectangular object which generates heat uniformly and dissipates it across its top and bottom surfaces. Fundamental heat transfer equations are used to determine the watts-per-foot dissipation that would cause a maximum cable temperature equal to the cable rating (typically 90°C). Temperature parameters are:



T_a = ambient temperature

T_c = average cable mass surface temperature

T_m = maximum cable temperature

The maximum temperature rise within the cable mass (T_m - T_c), is a function of conduction within the cable mass. T_c is a function of radiation and convection of the cable mass surface to the surrounding air at T_a.

The maximum temperature rise within the cable mass, per the Stolpe method, conservatively assumes that all cables are loaded to the same heat intensity as the most heavily loaded cable in the tray. The maximum heat intensity is multiplied by the cross-sectional area of the cable mass to obtain the hypothetical total heat dissipated per unit length of tray. This results in the highest possible temperature rise that could occur in the cable mass regardless of the distribution of the heavily loaded cables.

In the Diversity Method, the calculation of T_c, average cable mass surface temperature, is based on the model used by Stolpe of a thin box which generates heat internally and dissipates it into the surrounding air. However, it uses a more realistic value of dissipated heat than that which is advocated by Stolpe. The Stolpe method uses the value described above, but the realistic value, is usually much lower. It is recognized that, in most trays, all cables do not operate simultaneously at their rated ampacities, and in many cases only a small percentage dissipate significant heat at any time. For example, control circuits and power feeds to motor operated valves and other intermittent or seldom-used equipment may constitute much of the bulk of the tray fill while producing very little heat. The method credits diversity, thereby reducing some of the conservatism in the Stolpe method, while also providing verification that unacceptable hot spots will not occur. This is accomplished by utilizing the conservative Stolpe method to calculate the temperature rise within the cable mass, but utilizing a realistic value of total dissipation per unit length of tray to

calculate the average cable mass surface temperature. This value is calculated by summing the I^2R losses of all cables in the tray under worst-case loading conditions. This method results in a maximum permissible heat intensity value which is used to ensure that individual cables are not overloaded.

3.2 DETAILED METHODOLOGY - CONVENTIONAL

3.2.1 CKT software is utilized to calculate loading amperes at nominal network input voltage for 120VAC and 125VDC power cables as given in qualified "Network Configuration Models" data files. Power cables routed through trays are identified by comparing CKT output files to a qualified database listing all cables in trays. Input and output data files are identified in the CKT Results Summary Text Files.

3.2.2 Power cables and their attached loads are read from "Network Configuration Models" for 480V and above circuits by a routine called CABLE.EXE. Power cables in trays are identified by comparing these models to the qualified database of cables in trays. Loading amperes are calculated based simply on load characteristics at rated voltage, which are given in the loading characteristics databases. Cable impedance is conservatively neglected [Assumption 1.2.14]. Data is entered separately for parallel cables, Motor Control Centers, Load Centers, and loads identified as "Nodes". Data files used to develop 480V and above loading and the respective output files output files are listed in calculation 01-EC-ZA-300.

3.2.3 The data files created in Section 3.2.1 and Section 3.2.2 above are combined together to create POWRCBL.DBF. In this file, intermittent equipment is identified and load amps are set to zero. Where indicated in the SOURCE field, loading amps are modified to reflect values from the given source document.

3.2.4 Internally-developed software TA.EXE calculates cable ampacities based on the methods presented in IEEE Std 666. TA.EXE creates auditable output reports which contain all data necessary to verify calculated ampacity values. Date and time of all input and output data files are also shown in the verification reports. These reports are included in the parent calculation 01-EC-ZA-300.

3.2.5 Nominal ampacities for cables in randomly filled tray depend on tray depth of fill. Since ampacity decreases as fill depth increases, the tray with the greatest depth of fill provides the limiting case. Generally, tray fill is limited to 1.15", therefore ampacities are calculated based on a 1.15" depth of fill, unless the cable passes through a tray with a greater "as built" fill depth. Maximum ampacity after derating due to fill depth is 80% of the Reference 4.3 free air rating [Assumption 1.2.8].

3.2.6 Power cables may pass through tray with different thermal insulating characteristics e.g. fire stop, uncovered, covered, or fire protective wrap. If the cable passes through one or more trays with these routing conditions, appropriate derating factors must be applied to compensate for the heat retention effects. The derating factor for covered trays is conservatively applied to all "unwrapped" ampacities, unless it is confirmed the tray has no cover. The Thermo-Lag 330 derating factor is applied to all "wrapped" ampacities [Assumption 1.2.11].

3.2.7 Ampacities of cables in trays with Thermo-Lag 330 is currently a topic of concern in the industry, as noted in NRC Generic Letter 92-08. To facilitate incorporation of results from ongoing studies, ampacities are calculated and presented for each wrapped tray through which the cable passes.

3.2.8 13.8KV and 4.16KV cables are installed with maintained spacing of one cable diameter. Fill for maintained spacing trays estimates the horizontal width necessary to meet this spacing. Where this is not met, derating factors should be applied as given in Reference 4.3.

3.3 DETAILED METHODOLOGY - DIVERSITY METHOD

3.3.1 List all of the cables in the tray.

3.3.2 Calculate the nominal current of each cable (I_n) based on load equipment characteristics. Use 0 amps for intermittent loads.

3.3.3 Calculate the heat intensity of each cable (Q_c) based on nominal current. The cable cross-sectional area (A_c) is calculated as the area of a square whose sides are equal to the cable diameter (D) to account for interstices.

3.3.4 Identify the cable with the highest heat intensity. Multiply its nominal current (I_n) by 1.25 or calculate its maximum credible current (I_m). Calculate the maximum heat intensity (Q_{cm}) based on the higher current.

3.3.5 Calculate the total heat dissipation of the cable mass (q_m).

3.3.6 Calculate the cross-sectional area (A_m) and depth (d) of the cable mass.

3.3.7 Calculate the diversity factor (δ).

3.3.8 Solve the heat transfer equations to obtain the maximum allowable heat intensity (Q_m).

3.3.9 Calculate maximum heat dissipation of cable mass (q_a).

3.3.10 Verify that the derating factor, k_d, is less than or equal to the margin (M).

3.3.11 Internally-developed software TA.EXE performs the calculations described above for each tray section in the diversity method input file. TA.EXE creates auditable output reports which contain all data necessary to verify calculated values. Date and time of all input and output data files are also shown in the verification reports.

3.4 DETAILED METHODOLOGY - SOFTWARE

3.4.1 CKT is classified as Qualified Software in accordance with procedure 01AC-0CQ01: *Control of Non-Process Computer Software and Electronically Stored Data*. As such, output need not be verified in detail. TA.EXE and CABLE.EXE are classified as NQS (Non-Qualified Software) in accordance with procedure 01AC-0CQ01: *Control of Non-Process Computer Software and Electronically Stored Data*. As such, the output is independently verified.

3.4.2 TA.EXE performs all calculations to six decimal places. To accommodate the necessary data in the tables, calculated values have been rounded to no more than

three decimal places. When performing calculations with the rounded data, small differences may occur in comparison to the results presented. When results are marginally close to criteria, using the rounded values may push the results from acceptable to not acceptable, or visa versa. However, the results presented in the tables may be verified by performing calculations to the accuracy of the program.

3.5 GENERAL FORMULAS

3.5.1 Ambient Temperature Correction [Reference 4.3]

$$I' = I\sqrt{\frac{T'_c - T'_a - DELTATD'}{T_c - T_a - DELTATD} \times \frac{234.5 + T_c}{234.5 + T'_c}}$$

where:

T_c	=	conductor temperature, °C
Ta	=	ambient temperature, °C
DELTATD	=	dielectric loss temperature rise

Prime mark indicates the desired new parameters

3.5.2 Cable Operating Temperature Correction [Reference 4.4]

$$R_2 = R_1(1 + \alpha(T_2 - T_1))$$

where:

R_1	=	known cable resistance, Ω
R_2	=	new cable resistance, Ω
T_1	=	temperature for R1, °C
T_2	=	temperature for R2, °C
α	=	0.00323

3.5.3 Cable Ampacity [random filled tray [Reference 4.6]]

$$I = \sqrt{\frac{QA}{n_w Rac}}$$

where:

I	=	maximum allowable current for a conductor, Amperes
Q	=	maximum allowable heat intensity (watts/inch^2/foot)
A_c	=	cross sectional area of the cable [Assumption 1.2.9], sq. inches
n_w	=	number of conductors in cable
Rac	=	ac resistance of conductor at maximum operating temperature, Ω

3.5.4 Heat generation per unit area [Reference 4.6]]

$$Q = \frac{W}{dw}$$

where:

Q is as defined in 3.5.3, *W*, *d* and *w* are as defined in 3.5.5.

3.5.5 Total allowable heat generated in a cable tray (*W*) is found by solving the following equations iteratively. [Reference 4.2 and Reference 4.6]

3.5.5.1 $\Delta T = T_m - T_a = \Delta T_c + \Delta T_a$

3.5.5.2 $\Delta T_c = T_m - T_c$

3.5.5.3 $\Delta T_a = T_c - T_a$

3.5.5.4 $h = 0.101 \times \Delta T_a^{\frac{1}{4}}$

3.5.5.5 $\Delta T_c = \frac{W \rho d}{8w}$

3.5.5.6

$$W = hA_s \Delta T_a + \sigma A_s \varepsilon [(T_c + 273.15)^4 - (T_a + 273.15)^4]$$

where:

ΔT	=	system temperature Drop(°C)
T_m	=	maximum operating temperature of cable insulation in tray(°C)
T_a	=	ambient temperature(°C)
T_c	=	average cable mass surface temperature(°C)
ΔT_c	=	drop through cable mass(°C)
T_a	=	drop through air(°C)
W	=	heat dissipated in cable mass per unit length (watts/foot)
W	=	total allowable heat (watts/ft.)
$hA_s\Delta T_a$	=	the heat loss from the tray due to convection
$\sigma A_s \varepsilon [Tc^4 - T_a^4]$	=	the heat loss from the tray due to radiation
h	=	overall convection heat transfer coefficient for tray, (watts/ ft^2/°C)
w	=	width of cable mass/ tray (inches)
d	=	depth of cable mass, tray fill (inches)
A_s	=	surface area of cable mass per unit tray length = 2 x w/ 12(feet^2/foot)
σ	=	Stefan-Boltzman constant = 0.530 X 10-8 (watts/foot^2/°K^4)
ε	=	effective thermal emissivity of cable mass and tray surface = 0.8
ρ	=	thermal resistivity of cable mass, 400°C-cm/watt, 13.12(°C-ft/watt)

3.6 ADJUSTED AMPACITY FORMULAS

3.6.1 Heat Dissipation of Individual Cable

$$q_c = I^2 \cdot R \cdot n_c \cdot n_w$$

where:

q_c	=	heat dissipated in cable per unit length (watts/foot)
I	=	current (amps)
R	=	cable resistance per unit length (Ω/foot)
n_c	=	number of cables
n_w	=	number of wires within cable

3.6.2 Heat Intensity of Individual Cable

$$A_c = D^2 \cdot n_c \quad \text{[Assumption 1.2.9]}$$

$$Q_c = \frac{q_c}{A_c} = \frac{I^2 \cdot R \cdot n_w}{D^2}$$

where:

A_c	=	cross-sectional area of cable (inch^2)
D	=	diameter of cable (inches)
Q_c	=	heat intensity of individual cable (watts/inch^2/foot)

Use I_n to calculate Q_{cn} in order to identify most heavily-loaded cable. Use I_m for the most heavily-loaded cable to calculate Q_{cm}.

I_m	=	maximum current (amps)
I_n	=	nominal current (amps)
Q_{cn}	=	heat intensity of individual cable based on nominal current (watts/inch^2/foot)
Q_{cm}	=	heat intensity of most heavily-loaded cable based on maximum current (watts/inch^2/foot)

3.6.3 Heat Dissipation of Cable Mass

$$q_m = \sum q_c$$

where:

q_m	=	heat dissipated in cable mass per unit length (watts/foot)

3.6.4 Cross-Sectional Area of Cable Mass

$$A_m = \sum D^2 \cdot n_c$$ [Assumption 1.2.9]

where:

A_m = cross-sectional area of cable mass (inch^2)

3.6.5 Depth of Cable Mass

$$d = \frac{A_m}{w}$$

where:

d = depth of cable mass (inches)

w = width of cable mass/ tray (inches)

3.6.6 Diversity Factor

$$\delta = \frac{q_m}{A_m \cdot Q_{cm}}$$

where:

δ = diversity factor

3.6.7 Heat Flow Within Cable Mass

$$T_m - T_c = \frac{W \cdot \rho \cdot d}{8w}$$ [Section 3.5.5]

In accordance with the Stolpe method:

$$W = Q \cdot A_m = Q \cdot d \cdot w$$ [Section 3.5.4]

Therefore:

$$T_c = T_m - \left(\frac{Q \cdot d^2 \cdot \rho}{8}\right)$$

3.6.8 Heat Flow from Cable Mass Surface to Surrounding Air

$$W = hA_s(T_c - T_a) + \sigma A_s \varepsilon (T_{cK}^4 - T_{aK}^4)$$ [Section 3.5.5]

where:

T_{aK} = ambient temperature in °K = $T_a + 273.15$

T_{cK} = average cable mass surface temperature in °K = $T_c + 273.15$

$$h = 0.101\,(T_c - T_a)^{1/4} \quad \text{[Section 3.5.5]}$$

Therefore:

$$W = 0.101\,(T_c - T_a)^{1/4} A_s (T_c - T_a) + \sigma A_s \varepsilon\,((T_c + 273.15)^4 - (T_a + 273.15)^4)$$

Per the method described previously:

$$W = q_m = \delta Q d w$$

Therefore:

$$\delta Q d w = 0.101\,(T_c - T_a)^{1/4} A_s (T_c - T_a) + \sigma A_s \varepsilon\,((T_c + 273.15)^4 - (T_a + 273.15)^4)$$

3.6.9 Maximum Allowable Heat Intensity of Most Heavily-Loaded Cable

$$A_s = 2 \cdot \frac{w}{12} = \frac{w}{6}$$

combining the above:

$$\frac{0.016833}{d}(T_c - T_a)^{1/4}(T_c - T_a) + \frac{\sigma\varepsilon}{6d}((T_c + 273.15)^4 - (T_a + 273.15)^4) - \delta Q = 0$$

where:

$$T_c = T_m - \left(\frac{Q \cdot d^2 \cdot \rho}{8}\right)$$

For a tray of known depth of fill, diversity factor, ambient temperature, and maximum cable temperature, the maximum allowable heat intensity (Q_m) can be calculated by substituting values until equality is reached. This is best performed on a computer.

3.6.10 Maximum Heat Dissipation of Cable Mass

$$q_a = \delta Q_m d w$$

where:

q_a = maximum heat dissipated in cable mass per unit length (watts/foot)

3.6.11 Acceptance Criterion

T_m will not be exceeded if: $q_a \geq q_m$

The maximum heat dissipated in the cable mass can be written as

$$q_a = k_a^2 \cdot q_m$$

where k_a is a constant multiplier applied to each current in calculating q_m as in Section 3.6.3. Then:

$$k_a^2 = q_a / q_m$$

For routing conditions such as trays which are covered or wrapped with Thermo-Lag materials, an ampacity derating factor is applied. The allowable current must be derated by the appropriate constant multiplier, k_m. For example, Thermo-Lag requires derating of 38.9%, $k_d = 0.389$ and $k_m = 1 - k_d = 0.611$. Then the maximum heat dissipated in the cable mass is written:

$$q_a = \Sigma (k_m \cdot k_a \cdot I)^2 \cdot R$$

And:

$$\Sigma (k_m \cdot k_a \cdot I)^2 \cdot R \geq \Sigma I^2 \cdot R$$

$$k_m^2 \cdot k_a^2 \geq 1$$

$$k_m^2 \geq \frac{1}{q_a / q_m}$$

$$k_m \geq \sqrt{q_m / q_a}$$

$$1 - \sqrt{q_m / q_a} \geq k_d$$

Therefore, T_m will not be exceeded if:

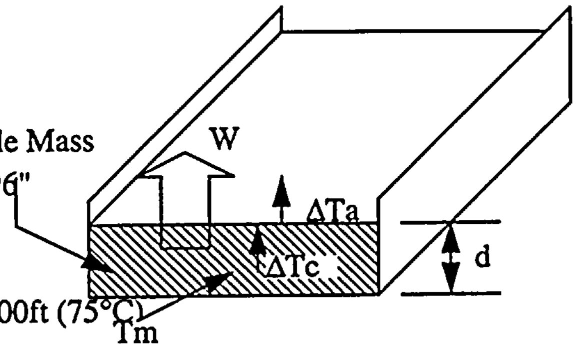
$k_d \leq M$

where:

M = Margin = $1 - \sqrt{q_m / q_a}$

3.7 EXAMPLES

3.7.1 Random Filled Tray



Given an unwrapped tray with:

Tm = 90°C   Ta = 50°C   d = 1.96"

diam = 0.750"   size = 4/0

$n_w = 1$ Rac = 0.061147 Ω/1000ft (75°C)

From 5.5.2 and 5.5.5:

A_c = diam^2 = 0.56250   As = 24*2/12 = 4

R_{90} = 0.061147/1000x(1+.00323(90 - 75)) = 0.0000641 Ω

$$\Delta T_c = T_m - T_c = 90 - T_c \ °C$$

$$\Delta T_a = T_c - T_a = T_c - 50 \ °C$$

$$h = 0.101 \times \Delta T_a^{\frac{1}{4}}$$

$$\Delta T_c = \frac{W\rho d}{8w} = \frac{W \times 13.12 \times 1.96}{8 \times 24} \ °C$$

$$W = hA_s\Delta T_a + \sigma A_s \varepsilon [(T_c + 273.15)^4 - (T_a + 273.15)^4] \text{ watts/ft}$$

Solving iteratively gives:

W = 95.64

From 5.5.3 and 5.5.4:

$$Q = \frac{W}{dw} = \frac{95.64}{1.96 \times 24} = 2.033$$

$$I = \sqrt{\frac{QA}{n_w R_{90}}} = \sqrt{\frac{2.033 \times 0.56250}{1 \times 6.41}} = 133.57A$$

Assumption 1.2.8 states that the ampacity is limited to 80% of the free air value . From Reference 4.3, free air ampacity at 40°C is 400A. From 3.5.1 at 50°C:

$$I' = 400\sqrt{\frac{90 - 50 - 0}{90 - 40 - 0} \times \frac{234.5 + 90}{234.5 + 90}} = 358A$$

80% gives I' = 286Amperes

Comparing the calculated ampacity to the limiting ampacity shows the calculated value to be lower. Therefore, the nominal ampacity of the cable is 133Amps. Since the tray is unwrapped, the derating factor for covered trays [Assumption 1.2.11] is applied giving a derated ampacity of:

$I_{derated}$ = 133Amps x 0.74 = 98Amps

3.7.2 Maintained Spacing - Power Distribution tray

Given an unwrapped tray with:

size = 4/0 n = 1 Ta = 60°C

From Reference 7.3:

I_{40} = 400 DELTATD = .15

From 5.5.1 at 60°C:

$$I' = 400\sqrt{\frac{90-60-0.15}{90-40-0.15} \times \frac{234.5+90}{234.5+90}} = 310A$$

Applying the derating factor [Assumption 1.2.11] gives:

$I_{derated}$ = 310Amps x 0.74 = 229Amps

Sample Calculation

Given Tray: 1EZA1DATKBB, which is wrapped with Thermo-Lag 330 and T_m = 90°C

TRAY: 1EZA1DATKBB									
Cable	Code	D	nc	nw	R	Load	In	qc	Qc
1ESG51AC1RA	A281	0.455	1	2	0.00215	1EPNAD2527	0.12	0.00	0.00
1ESG02AC1RB	A781	0.780	1	9		1JSGAUV138	0.00		
1ESG51AC2RA	A281	0.455	1	2	0.00215	1EPNAD2525	0.12	0.00	0.00
1ESG02AC1KC	8291	0.470	1	2		1JSGAUV138	0.00		
1ESG02AC1KB	81K1	0.960	2	1		1JSGAUV138	0.00		
1ESI55AC1RE	A271	0.420	1	2		1EZJAC03	0.00		
1ESI36AC1KA	8391	0.490	1	3	0.00135	1MSIAP05	4.60	0.09	0.36
1ESI38AC1RC	A471	0.480	1	4		1ESIAJ113	0.00		
1ESI55AC2RE	A271	0.420	1	2		1EZJAC03	0.00		
1ESB01AC1RQ	A281	0.455	1	2	0.00215	1EPNAD2514	0.84	0.00	0.01
1EPN02AC1KB	A281	0.455	1	2	0.00215	1EPHAD3301	0.18	0.00	0.00
1ESB02AC1KM	8291	0.470	2	2	0.00135	1EPKAM4108	0.11	0.00	0.00
1EPN01AC1KA	81H1	0.640	2	1		1EPNAV25	0.00		
1ESG02AC1KA	81K1	0.960	2	1		1JSGAUV138	0.00		
1ESG01AC1KC	8291	0.470	1	2		1EZAA3BKKJ 02	0.00		
1ESG01AC1KA	81K1	0.960	2	1		1JSGAUV134	0.00		
1ESG01AC1KB	81K1	0.960	2	1		1JSGAUV134	0.00		
1EPK04AC2KA	81K1	0.960	3	1		1EPKAH15	0.00		
1EZS01AC2RH	A271	0.420	1	2		1EPGAL35C	0.00		
1EZS01AC2RG	A271	0.420	1	2		1EPGAL31C	0.00		
1EZS01AC3RB	82B1	0.650	1	2		SPARE	0.00		
1EZS01AC1KR	8391	0.490	1	3		DUMMY	0.00		
1EZS01AC1KP	83B1	0.690	1	3		DUMMY	0.00		
1EZS41AC1RL	A271	0.420	1	2		1ESIAJ113	0.00		

TRAY: 1EZA1DATKBB									
Cable	Code	D	nc	nw	R	Load	In	qc	Qc
1EZS01AC6RP	8391	0.490	1	3		DUMMY	0.00		
1EZS41AC1RI	CE61	0.357	1	2		1JSDAC08	0.00		
1EZA03AC1KU	82B1	0.650	1	2	0.00085	1EZAAC04	12.00	0.24	0.58
1EZA03AC1RO	82B1	0.650	1	2	0.00085	1EPKAD2110	4.34	0.03	0.08
1EZD01AC1KA	8391	0.490	1	3		DUMMY	0.00		
1EZA03AC1RM	82B1	0.650	1	2	0.00085	1EPKAD2109	3.35	0.02	0.05
1EZS01AC1KN	82D1	0.800	1	2		SPARE	0.00		
1EZS01AC1KM	82D1	0.800	1	2		SPARE	0.00		
1EZS01AC1KK	82D1	0.800	1	2		SPARE	0.00		
1EZS01AC1KL	82D1	0.800	1	2		SPARE	0.00		
1EAF04AC1KA	81H1	0.640	2	1		1EPKAM4112	0.00		
1ECH26AC1RD	A281	0.455	1	2		1EPGAL35C	0.00		
1ECH24AC1RG	A281	0.455	1	2	0.00215	1EPHAD3711	0.22	0.00	0.00
1ECH26AC1RJ	A271	0.420	1	2		1EPGAL35C	0.00		
1ECH24AC1RD	A281	0.455	1	2		1EPGAL31C	0.00		
1EAF57AC1RD	82D1	0.800	1	2	0.00034	1EPKAD2118	0.99	0.00	0.00
1EDG02AC1RD	A281	0.455	1	2	0.00215	1EPHAD3715	0.12	0.00	0.00
1ECH26AC1RL	A281	0.455	1	2	0.00215	1EPHAD3712	0.22	0.00	0.00
1EDG02AC1KA	83D1	0.900	1	3	0.00034	1MDGAP04	24.00	0.58	0.72
1EDG05AC1KA	8391	0.490	1	3	0.00135	1MDGAP01	6.90	0.19	0.80
1EAF07AC1KA	83E1	1.020	1	3		1EAFAJ01	0.00		
1EAF07AC1KB	82E1	0.960	1	2		1EAFAJ01	0.00		
1EAF04AC1KB	81H1	0.640	2	1		1EPKAM4112	0.00		
1EAF10AC1KB	81I1	0.750	2	1		1JAFAUV37	0.00		
1EAF10AC1KA	81I1	0.750	2	1		1JAFAUV37	0.00		
1EAF07AC1RG	A671	0.605	1	7		1JAFAE01	0.00		
1EAF07AC1RJ	A871	0.785	1	12		1JAFAE01	0.00		

TRAY: 1EZA1DATKBB									
Cable	Code	D	nc	nw	R	Load	In	qc	Qc
1EPK04AC1KA	81K1	0.960	3	1	0.00004	1EPKAH11	96.23	1.12	0.41
1EHA17AC1RH	CE61	0.357	1	2		1JSDAC07	0.00		
1EHA17AC1RG	A271	0.420	1	2		1JHAAZSL03	0.00		
1EHF04AC1RS	A271	0.420	1	2		1EZJAC02	0.00		
1EHA17AC1RC	A471	0.480	1	4		1EHAAJ02	0.00		
1EHA16AC1RX	CE61	0.357	1	2		1JHAAZSL06	0.00		
1EPG21AC4KA	8291	0.470	1	2	0.00135	1EPHAD3716	1.99	0.01	0.05
1EHS07AC1KA	8391	0.490	1	3	0.00135	1MHSAJ01	13.50	0.74	3.08
1EPG21AC1KA	82C1	0.710	1	2	0.00053	1EPHAD3305	3.59	0.01	0.03
1EES03AC1KM	82E1	0.960	1	2	0.00021	1EPKAD2107	10.80	0.05	0.05
1EEW03AC1RA	A771	0.705	1	9		1JEWAUV145	0.00		
1EEW03AC2KA	8391	0.490	1	3	0.00135	1JEWAUV65	0.75	0.00	0.01
1EEW03AC1KA	8391	0.490	1	3	0.00135	1JEWAUV145	0.75	0.00	0.01
1EHA16AC1RT	A271	0.420	1	2		1JHAAZSL06	0.00		
1EHA16AC1RQ	A271	0.420	1	2		1JHAAZSH06	0.00		
1EEW03AC2RA	A771	0.705	1	9		1JEWAUV65	0.00		
1EHA16AC1RP	A271	0.420	1	2		1JHAAZSL06	0.00		

A_m: 37.43 q_m: 3.10

Cable with highest heat intensity:

Cable: 1EHS07AC1KA I_n: 13.5 amps

Maximum Current in Cable 1EHS07AC1KA

$$125\%\ \text{Full Load Current} = 1.25 \cdot I_n = 1.25 \cdot 13.5 = 16.875$$

However, 1EHS07AC1KA feeds spray pond pump house exhaust fan 1MHSAJ01.

Characteristics of the fan are:

Brake horsepower: 9.5 (ref. 01-E-ZZI-003)

Power factor: 0.757 (ref. 01-E-ZZI-003)

Efficiency: 0.908 (ref. 01-E-ZZI-003)

Minimum operating voltage: 388 (ref. 01-EC-MA-221, Table 5-3, "Loss of coolant accident—Manual" mode)

Therefore maximum credible current (I_m) is:

$$I_m = \frac{746 \cdot 9.5}{0.757 \cdot 0.908 \cdot 388 \cdot \sqrt{3}} = 15.3 \text{ amps}$$

Maximum heat intensity (Q_{cm})

$$Q_{cm} = \frac{I_m^2 \cdot R \cdot n_w}{D^2} = \frac{15.3^2 \cdot 0.00135 \cdot 3}{0.49^2} = 3.95$$

Diversity Factor (δ)

$$\delta = \frac{q_m}{A_m \cdot Q_{cm}} = \frac{3.10}{37.43 \cdot 3.95} = 0.021$$

Solving the heat transfer equations in Section 3.6.9 gives the maximum allowable heat intensity:

$$Q_m = 11.671$$

Maximum heat dissipation of cable mass:

$$q_a = \delta Q_m dw = \delta Q_m A_m = 0.021 \cdot 11.671 \cdot 37.43 = 9.153$$

Margin:

$$M = 1 - \sqrt{q_m / q_a} = 1 - \sqrt{3.10/9.153} = 0.418$$

Derating Factor for Tray Wrapped in Thermo-Lag

$$k_d = 0.389 < M$$

Since $k_d \leq M$, cable temperature will not exceed T_m

4. REFERENCES

4.1 IEEE Std 666-1991: *IEEE Design Guide for Electric Power Service Systems for Generating Stations*

4.2 NEMA WC 51-86/ ICEA P-54-440: *Ampacities of Cables in Open-top Cable Trays*

4.3 AIEE Pub. No. S-135-1-62/IPCEA Pub. No. P-46-426: *Power Cable Ampacities*

4.4 NFPA 70-1990: *National Electrical Code*, Table 8

4.5 NFPA 70-1990: *National Electrical Code*, Articles 100 A, 220-10 b, and 240-3

4.6 "Ampacities for Cable in Randomly Filled Trays," Stolpe, J. IEEE Transactions of Power Apparatus and Systems. vol. PAS-90, pp.962-973.

4.7 "The Calculation of the Temperature Rise and Load Capability of Cable Systems," J. H. Neher, M. H. McGrath. AIEE Transactions, pt. III (Power Apparatus and Systems), vol. 76, Oct. 1957, pp. 752-72.

4.8 UFSAR 8.3.1.4.3

4.9 UFSAR 8.3.1.1.3.2

4.10 UFSAR Table 9.4-2

4.11 Electrical Design Criteria Manual, 4.3.3.1.A

4.12 UFSAR Appendix 3E

SAMPLE CALCULATION

TABLE 3

CABLE CODE

	1ST DIGIT	2ND DIGIT	3RD DIGIT	4TH DIGIT	5TH DIGIT
	VOLTAGE	NO. OF CONDUCTORS	SIZE	MISC.	MISC
1	15KV ARMORED OR TRIPLEXED	1/C	#24 AWG	RED	
2	15KV SHIELDED	2/C	#22	GREEN	
3	CONAX	3/C	#20	YELLOW	
4	CONAX	4/C	#19	BLUE	
5	5 KV ARMORED OR TRIPLEXED	5/C	#18		
6	5 KV SHIELDED	7/C	#16		
7	CONAX	9/C	#14		
8	LOW VOLTAGE POWER 90°C	12/C	#12		
9	ALL OTHER VENDORS	8/C	#10		
A	LOW VOLTAGE CONTROL 90°C	50/C	#9 (19/22)	16PR	
B	LOW VOLTAGE CONTROL HI TEMP 200°C	80/C	#8	2PR & 18/C #18	
C	LOW VOLTAGE INSTR. 90°C SHLD & TWST	27/C	#6		
D	LOW VOLTAGE INSTR. HI TEMP SHIELDED	30/C	#4		
E	COMMUNICATIONS SHIELDED (NOTE 6)	1PR	#2		
F	THERMOCOUPLE CHROMEL-ALUMEL	2PR	FIBER OPTIC		
G	THERMOCOUPLE CHROMEL-CONSTANTAN	3PR	#1/0		
H	THERMOCOUPLE COPPER-CONSTANTAN	4PR	#2/0		
I	THERMOCOUPLE IRON-CONSTANTAN	6PR	#4/0		NOTE 8
J	93Ω/750V	8PR	#250KCMIL		
K	75Ω/2300V	11PR	#350KCMIL		
L	75Ω/4000V	12PR	#500KCMIL	9PR	
M	62Ω/2300V	25PR	#750KCMIL	19PR	
N	50Ω/1400V	50PR	#1000KCMIL		
O	TECHNOLOGY FOR ENERGY CORP	75PR	#1350KCMIL		
P	ENERGY INCORPORATED	10/C	#1500KCMIL		
Q	FESTOON	14/C	RG-62A		
R	ROCKWELL FURN. PREFAB	M/C-M/PR	MULTI-SIZE		
S	FESTOON-VT TECH	COAX	RG-11A/U	SHIELDED	
T	HONEYWELL FURN. PREFAB	TRIAX	RG-59/U		
U	BECHTEL PURCH. SPECIAL CABLE	11/C	RG-59B/U	BECHTEL SPEC	
V	FOXBORO	48/C	RG-71B/U	4-3/C SHLD	
W	WESTINGHOUSE	16/C	RG-58C/U		
X	BETA PRODUCTS	5PR	.412 COAX		
Y	COMBUSTION ENGINEERING	20PR	PLUG 1 END	C-E SPEC	
Z	GENERAL ELECTRIC	SHIELDED	PLUG 2 ENDS		
—		SEE COL 4 # OF COND			

FOURTH COLUMN—COLOR APPLIES TO JACKET OF CLASS Q CABLES
23K 15KV SHIELDED 3/C-350MCM BLACK
63K1 5KV SHIELDED 3/C-350MCM RED
A77 600 VOLT CONTROL 90°C 9/C-14 BLACK
A772 600 VOLT CONTROL 90°C 9/C-14 GREEN
C--5 THRU Z EXAMPLE: INSTRUMENT CABLE.WITH MULTI-COND + TWISTED PR CONFIGURATION
COLUMN 4 A THRU Z = SEQUENCE NO. OF VENDOR PREFAB CABLE FAMILY

NOTES CONT.: 8. THE FIFTH DIGIT REFLECTS A VARIATION OF AN EXISTING CABLE CODE TO IDENTIFY SPECIFIC DEVIATIONS OR CABLE CHARACTERISTICS. REFER TO THE EESBO "B2" COMPONENT CHARACTERISTIC LIBRARY FILE FOR FURTHER CLARIFICATION OF A CODE WITH A FIFTH DIGIT.

9. REFER TO THE GOVERNING DOCUMENT NATH 60AC-OCC01, PLANT NUMBERING, APPENDIX C AND APPENDIX D, TO VERIFY SYSTEM DESIGNATORS LISTED IN THIS DRAWING, AND FOR ADDITIONAL SYSTEMS AND FACILITIES. (9)

NOTE:
1. FOR ADDITIONAL INFROMATION SEE INTERNAL PROCEDURES MANUAL.
2. FOR SYMBOLS & ABBREVIATIONS USED IN THE LOGIC DIAGRAMS REFER TO DRAWING NO'S 13-J-ZZL-010, 13-J-ZZL-012 & 13-J-ZZL-013.
3. FOR SYMBOLS, ABBREVIATIONS & LEGEND USED IN THE P&I & FLOW DIAGRAMS REFER TO DRAWING NO'S 13-M-ZZP-001 THRU 13-M-ZZP-004
4. FOR SYMBOLS & DETAILS USED IN COMMUNICATIONS REFER TO DRAWING NO'S 13-E-ZZQ-001 THRU 13-E-ZZQ-003.
5. THIS SYMBOL IS NOT INDICATED IN ANSI Y32.2-1975.
6. *CABLE CODE EFZ CABLES ARE NOT SHIELDED.*
7. *HORSEPOWER RATINGS ARE NAMEPLATE ONLY AND MAY NOT REPRESENT ACTUAL LOAD.*

CABLE CODES

INTERNAL CONTROL NO. 18601 -273-4H - DWG -003

NQF

TABLES 2 & 3. IC CHANGES							
TABLES 2 & 3 ADDED DESIGNATION							
CONSTRUCTION							
REVISIONS	DR	CHK	DGS	ENG	EGS	CHF ENG	PRJ ENG

BECHTEL
LOS ANGELES

ARIZONA NUCLEAR POWER PROJECT
PALO VERDE NUCLEAR GENERATING STATION

ELEMENTARY DIAGRAM
GENERAL
SYMBOL LIST

SCALE	JOB NO.	DRAWING NO.	REV
NONE	10407	13-E-ZZB-007	9

Figure 5-1: Calculation Overview

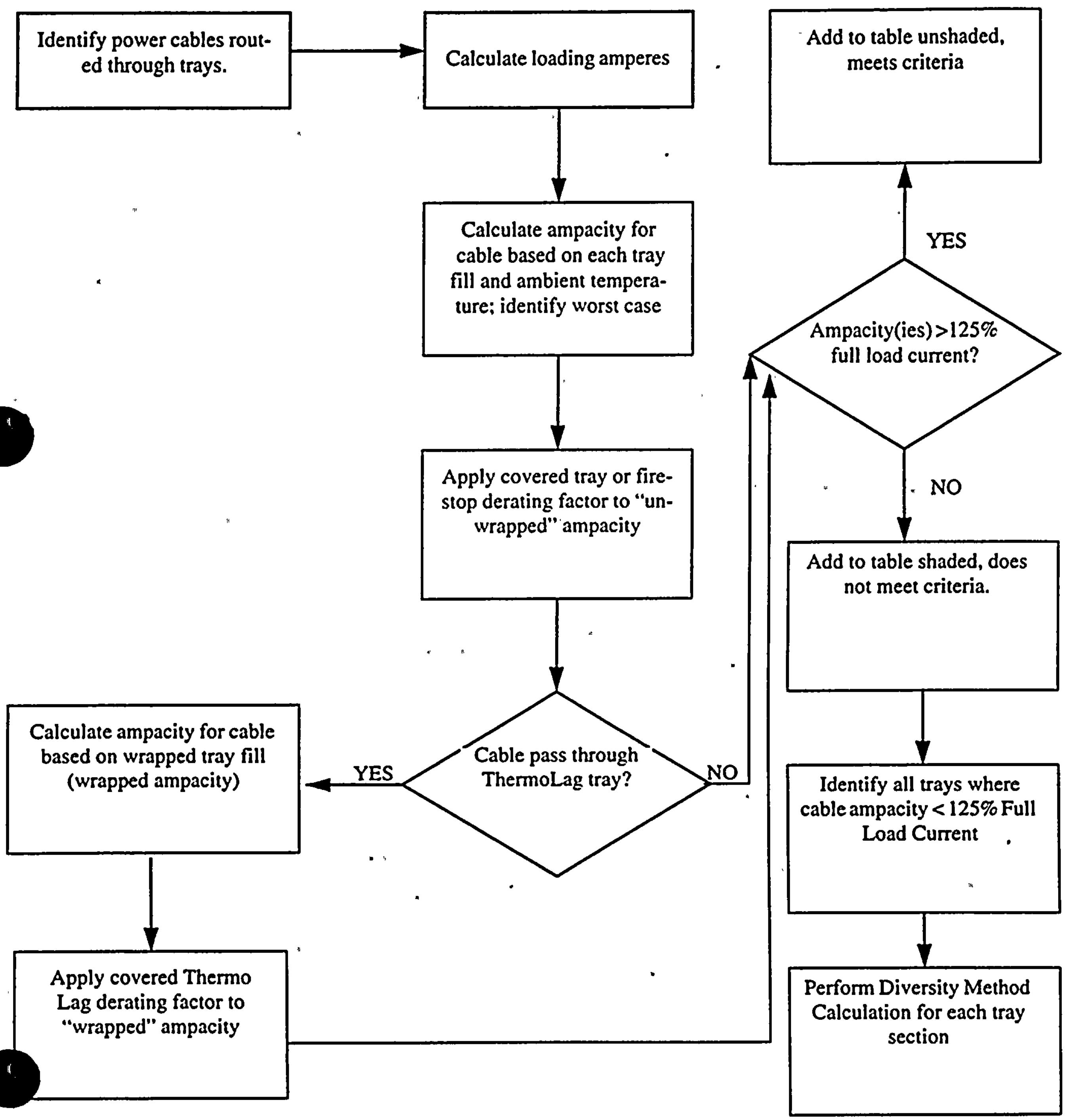


Figure 5-2: Preparation of 120V AC and 125V DC Input Files

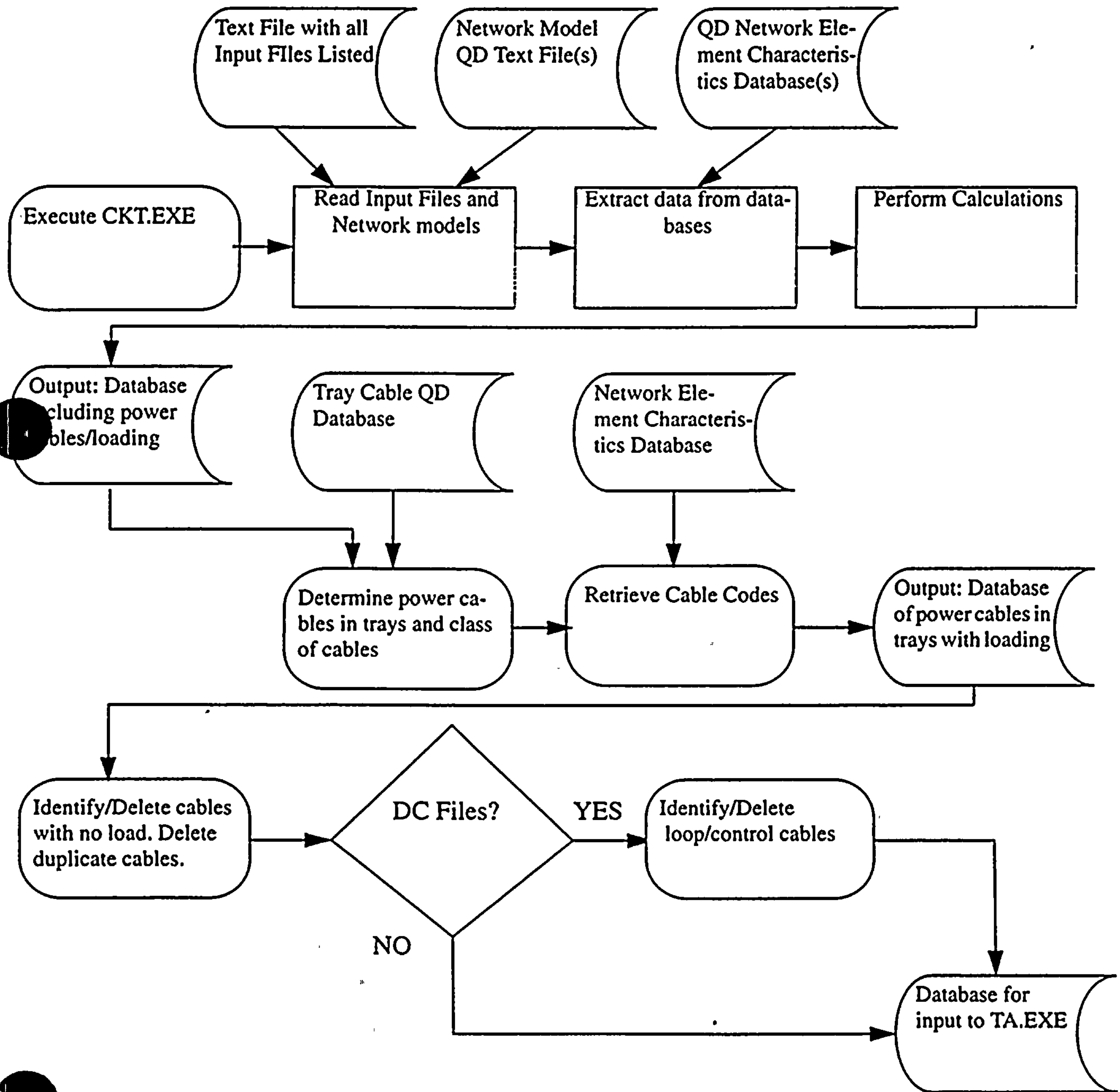
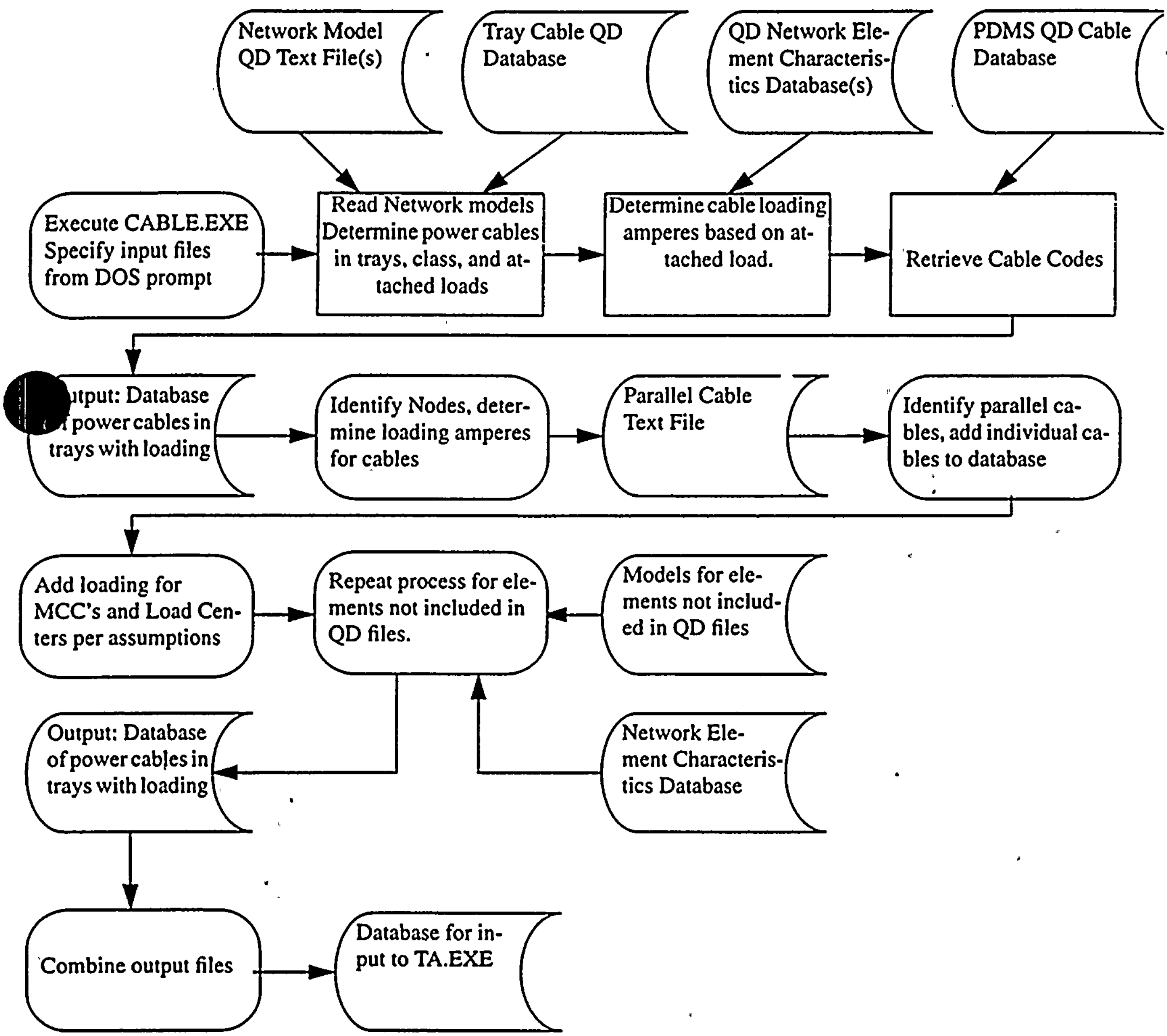


Figure 5-3: Preparation of 480V and Above Input Files



PROGRAM OUTPUT

TITLE Ampacities of Cables in Trays CALC. NO 01-EC-ZA-300

SUBJECT PVNGS Unit 1 SHEET NO. 5944 of 5953

ORIGINATOR Bryan J Hill DATE 3-15-96

INDEPENDENT VERIFIER [signature] DATE 3-20-96

8.6 OKONITE CABLES BULLETIN EHB-81

Introduction

This booklet is designed to help engineers in the selection of conductor sizes and help in the installation of cable systems. Information from many sources has been compiled in this booklet for your convenience.

The ampacity data applies to thermosetting (vulcanized) insulations rated at 90 C conductor temperature.

The information in Section I provides general conductor data. Tables are provided which give the cross sectional area, number of strands, outside diameter, and weight of solid wire, class B and C strandings, and class G, H and I flexible strandings. There is also data available to calculate the a c or d c resistance of conductors at many temperatures and frequencies.

Section II contains the necessary tables and formulas to determine the required current for a cable circuit.

Normally, the ampacity of a cable is limited by heating but, for some low voltage circuits the voltage drop is important. For this reason, in Section III information on voltage regulation is included. Formulas for calculating the voltage drop are given along with a nomogram for determining the reactance of conductors.

For some applications large short circuit currents must be carried. Section IV contains short circuit ampacities for conductors and shields that may be useful in some applications.

The purpose of shielding and the effects of grounding shields are discussed in Section V. Tables give the voltages above which shielding should be considered. Formulas for calculating shield losses associated with multi-grounded shields are presented.

Ampacity tables and various correction factors are given in Section VI. The conditions used in calculating table values are given at the top of each table. The appropriate correction factor for any installation condition varying from those for which the tables were calculated should be used. Also included is the National Electrical Code (1978, 600 Volt ampacity table).

Cable failures may result from poor installation practices. Compliance with the procedures outlined in Section VII may prolong the life of a cable. Information on conduit, buried, borehole, and self-supporting installations is provided.

Information on high voltage d c proof testing, reel capacities, jacket materials selection, and other miscellaneous information is given in Sections VIII and IX.

Table of Contents

PROGRAM OUTPUT

TITLE Ampacities of Cables in Trays — CALC. NO 01-EC-ZA-300

SUBJECT PVNGS Unit 1 — SHEET NO. 5946 of 5953

List of Tables

List of Tables

General Conductor Information

Stranding

Flexible stranding

Table 1-2

CONDUCTOR AWG or MCM	CLASS G • Number of Wires	CLASS G Diameter of Each Wire Mils	CLASS G Approx. OD Inches	CLASS G Weight Lbs. per 1000 Ft.	CLASS H • Number of Wires	CLASS H Diameter of Each Wire Mils	CLASS H Approx. OD Inches	CLASS H Weight Lbs. per 1000 Ft.	CLASS I • Number of Wires	CLASS I Diameter of Each Wire Mils	CLASS I Approx. OD Inches	CLASS I Weight Lbs. per 1000 Ft.
14	49	9.2	0.083	12.8								
12	49	11.6	0.104	20.3								
10	49	14.6	0.131	32.3					26	20.1	0.125	32.5
8	49	18.4	0.166	51	133	11.1	0.167	52	41	20.1	0.156	51
6	49	23.1	0.208	82	133	14.0	0.210	82	63	20.1	0.207	80
4	49	29.2	0.263	130	133	17.7	0.266	132	105	20.1	0.263	134
2	49	36.8	0.331	207	133	22.3	0.335	208	161	20.1	0.319	205
1	133	25.1	0.377	264	259	18.0	0.378	266	210	20.1	0.367	267
1/0	133	28.2	0.423	334	259	20.2	0.424	334	266	20.1	0.441	342
2/0	133	31.6	0.474	419	259	22.7	0.477	422	342	20.1	0.500	439
3/0	133	35.5	0.533	529	259	25.5	0.536	533	418	20.1	0.549	537
4/0	133	39.9	0.599	668	259	28.6	0.601	670	532	20.1	0.613	683
250	259	31.1	0.653	795	427	24.2	0.653	795	637	20.1	0.682	825
300	259	34.0	0.714	945	427	26.5	0.716	953	735	20.1	0.737	955
350	259	36.8	0.773	1110	427	28.6	0.772	1110	882	20.1	0.800	1145
400	259	39.3	0.825	1265	427	30.6	0.826	1270	980	20.1	0.831	1270
500	259	43.9	0.922	1585	427	34.2	0.923	1590	1225	20.1	0.941	1590
600	427	37.5	1.013	1910	703	29.2	1.022	1920	1470	20.1	1.027	1905
750	427	41.9	1.131	2385	703	32.7	1.145	2410	1862	20.1	1.235	2435
1000	427	48.4	1.307	3180	703	37.7	1.320	3205	2527	20.1	1.427	3305
1250	427	54.1	1.461	3975	703	42.2	1.477	4015	3059	20.1	1.564	4000
1500	427	59.3	1.601	4775	703	46.2	1.617	4815	3724	20.1	1.715	4875
1750	703	49.9	1.747	5620	1159	38.9	1.751	5625	4389	20.1	1.880	5745
2000	703	53.3	1.866	6415	1159	41.5	1.868	6400	4921	20.1	2.003	6440

• Per IPCEA S-68-516

Specifications applying to conductors

COPPER CONDUCTORS		ALUMINUM CONDUCTORS	
Solid, tinned, annealed	ASTM B33	Solid, hard drawn EC-H19	ASTM B230
Solid, alloy-coated, annealed	ASTM B189	Solid, 3/4 hard EC-H16 or EC-H26	ASTM B262
Solid, plain, bare, annealed	ASTM B3	Solid, 1/2 hard EC-H14 or EC-H24	ASTM B323
Concentric-stranded, plain or coated	ASTM B8	Concentric-stranded	ASTM B231
Rope-lay-stranded, bunched members	ASTM B172	Compact-stranded	ASTM B400
Rope-lay-stranded, concentric members	ASTM B173		
Bunch-stranded	ASTM B174		
Compact-stranded	ASTM B496		

Compact and Compressed Diameters

Table 1-1A

Conductor Size AWG or MCM	Number of Wires	Compact Diameter inches	Compress Diameter inches
8	7	0.133	–
6	7	0.167	–
4	7	0.211	–
2	7	0.266	–
1	19	0.299	.321
1/0	19	0.336	.361
2/0	19	0.376	.405
3/0	19	0.423	.456
4/0	19	0.475	.511
250	37	0.520	.557
300	37	0.570	.610
350	37	0.616	.659
400	37	0.659	.706
500	37	0.736	.788
600	61	0.813	.866
750	61	0.908	.970
800	61	0.938	1.000
900	61	0.999	1.060
1000	61	1.060	1.116

Solid and concentric stranding Table 1-1

Conductor Size AWG or MCM	Circular Mil Cross-Sectional Area	Sq. MM	SOLID			CLASS "B" STRANDING			CLASS "C" STRANDING			CONDUCTOR WEIGHT Class "B" & "C" Strandings (lb./M ft.)	
			Conductor Diameter Mils	Conductor Weight (lb./M ft.) Aluminum	Conductor Weight (lb./M ft.) Copper	Number of Wires	Diameter of Each Wire Mils	Conductor Diameter (in.)	Number of Wires	Diameter of Each Wire Mils	Conductor Diameter (in.)	Aluminum	Copper
24	404	0.205	20.1	–	1.22	7	7.6	0.023	–	–	–	–	1.24
22	640	0.324	25.3	–	1.94	7	9.6	0.029	–	–	–	–	1.98
20	1,020	0.519	32.0	0.942	3.10	7	12.1	0.036	–	–	–	–	3.15
19	1,290	0.653	35.9	1.19	3.90	7	13.6	0.041	–	–	–	–	3.98
18	1,620	0.823	40.3	1.49	4.92	7	15.2	0.046	–	–	–	–	5.01
16	2,580	1.31	50.8	2.38	7.81	7	19.2	0.058	–	–	–	–	7.97
14	4,110	2.08	64.1	3.78	12.44	7	24.2	0.073	19	14.7	0.074	–	12.7
12	6,530	3.31	80.8	6.01	19.77	7	30.5	0.092	19	18.5	0.093	6.13	20.2
10	10,380	5.26	101.9	9.56	31.43	7	38.5	0.116	19	23.4	0.117	9.75	32.0
9	13,090	6.63	114.4	12.04	39.63	7	43.2	0.130	19	26.2	0.131	12.3	40.4
8	16,510	8.37	128.5	15.20	50.0	7	48.6	0.146	19	29.5	0.146	15.15	51.0
7	20,820	10.55	144.3	19.16	63.03	7	54.5	0.164	19	33.1	0.166	19.16	64.2
6	26,240	13.30	162.0	24.15	79.4	7	61.2	0.184	19	37.2	0.186	24.60	81.0
5	33,090	16.67	181.9	30.45	100.2	7	68.8	0.206	19	41.7	0.209	31.1	102.0
4	41,740	21.15	204.3	38.44	126.4	7	77.2	0.232	19	46.9	0.235	39.20	129.0
3	52,620	26.67	229.4	48.43	159.3	7	86.7	0.260	19	52.6	0.263	49.4	162.0
2	66,360	33.62	257.6	61.07	200.9	7	97.4	0.292	19	59.1	0.296	62.30	205.0
1	83,690	44.21	289.3	77.03	253.3	19	66.4	0.332	37	47.6	0.333	78.60	258.0
1/0	105,600	53.49	324.9	97.15	319.6	19	74.5	0.373	37	53.4	0.374	99.10	326.0
2/0	133,100	67.43	364.8	122.5	402.9	19	83.7	0.419	37	60.0	0.420	125.0	411.0
3/0	167,800	85.01	409.6	154.4	507.9	19	94.0	0.470	37	67.3	0.471	157.0	518.0
4/0	211,600	107.20	460.0	194.7	640.5	19	105.5	0.528	37	75.6	0.529	199.0	653.0
250	–	127.0	–	–	–	37	82.2	0.575	61	64.0	0.576	235.0	772.0
300	–	152.0	–	–	–	37	90.0	0.630	61	70.1	0.631	282.0	926.0
350	–	177.0	–	–	–	37	97.3	0.681	61	75.7	0.681	329.0	1081.0
400	–	203.0	–	–	–	37	104.0	0.728	61	81.0	0.729	376.0	1235.0
500	–	253.0	–	–	–	37	116.2	0.813	61	90.5	0.815	469.0	1544.0
600	–	304.0	–	–	–	61	99.2	0.893	91	81.2	0.893	563.0	1853.0
750	–	380.0	–	–	–	61	110.9	0.998	91	90.8	0.999	704.0	2316.0
1000	–	507.0	–	–	–	61	128.0	1.152	91	104.8	1.153	939.0	3088.0
1250	–	633.0	–	–	–	91	117.2	1.289	127	99.2	1.290	1173.0	3859.0
1500	–	760.0	–	–	–	91	128.4	1.412	127	108.7	1.413	1408.0	4631.0
1750	–	887.0	–	–	–	127	117.4	1.526	169	101.8	1.527	1643.0	5403.0
2000	–	1010.0	–	–	–	127	125.5	1.632	169	108.8	1.632	1877.0	6175.0
2500	–	1263.0	–	–	–	127	140.3	1.824	169	121.6	1.824	2370.0	7794.0

Resistance in Ohms per 1000 feet per conductor at 20C and 25C of solid wire and class B concentric strands copper and aluminum conductor

Table 1-3

Conductor Size, Awg or MCM	ANNEALED UNCOATED COPPER ANNEALED ALUMINUM — Solid 20C CU	Solid 20C AL	Solid 25C* CU	Solid 25C* AL	Stranded Class B 20C CU	Stranded Class B 20C AL	Stranded Class B 25C* CU	Stranded Class B 25C* AL	ANNEALED COATED COPPER — Solid 20C CU	Solid 25C* CU	Stranded Class B 20C CU	Stranded Class B 25C* CU
24	25.7	—	26.2	—	—	—	—	—	26.8	27.3	—	—
22	16.2	—	16.5	—	—	—	—	—	16.9	17.2	—	—
20	10.1	—	10.3	—	10.3	—	10.5	—	10.5	10.7	11.0	11.2
19	8.05	—	8.21	—	—	—	—	—	8.37	8.53	—	—
18	6.39	—	6.51	—	6.51	—	6.64	—	6.64	6.77	6.92	7.05
16	4.02	—	4.10	—	4.10	—	4.18	—	4.18	4.26	4.35	4.44
14	2.52	4.14	2.57	4.22	2.57	—	2.62	—	2.62	2.68	2.68	2.73
12	1.59	2.60	1.62	2.66	1.62	2.65	1.65	2.70	1.62	1.68	1.68	1.72
10	0.999	1.64	1.02	1.67	1.02	1.67	1.04	1.70	1.04	1.06	1.06	1.08
9	0.792	1.30	0.808	1.32	0.808	1.33	0.824	1.35	0.816	0.831	0.840	0.857
8	0.628	1.03	0.641	1.05	0.641	1.05	0.654	1.07	0.646	0.659	0.666	0.679
7	0.498	.817	0.508	.833	0.518	.833	0.518	0.850	0.513	0.523	0.528	0.539
6	0.395	.648	0.403	.661	0.403	.661	0.410	0.674	0.407	0.415	0.419	0.427
5	0.313	.514	0.319	.524	0.326	.524	0.326	0.535	0.323	0.329	0.333	0.339
4	0.248	.407	0.253	.415	0.253	.416	0.259	0.424	0.256	0.261	0.264	0.269
3	0.197	.323	0.201	.330	0.205	.330	0.205	0.336	0.203	0.207	0.209	0.213
2	0.156	.256	0.159	.261	0.159	.262	0.162	0.267	0.161	0.164	0.166	0.169
1	0.124	.203	0.126	.207	0.126	.206	0.129	0.211	0.128	0.130	0.131	0.134
1/0	0.0982	.161	0.100	.164	0.100	.165	0.102	0.168	0.101	0.103	0.104	0.106
2/0	0.0779	.128	0.0795	.130	0.0795	.131	0.0811	0.133	0.0798	0.0814	0.0827	0.0843
3/0	0.0618	.101	0.0630	.103	0.0630	.103	0.0642	0.105	0.0633	0.0645	0.0656	0.0668
4/0	0.0490	.0803	0.0500	.082	0.0500	.0821	0.0509	0.0836	0.0502	0.0512	0.0515	0.0525
250	—	—	—	—	0.0423	.0695	0.0431	0.0708	—	—	0.0440	0.0449
300	—	—	—	—	0.0353	.0579	0.0360	0.0590	—	—	0.0367	0.0374
350	—	—	—	—	0.0302	.0496	0.0308	0.0505	—	—	0.0314	0.0320
400	—	—	—	—	0.0264	.0434	0.0270	0.0442	—	—	0.0272	0.0278
500	—	—	—	—	0.0212	.0348	0.0216	0.0354	—	—	0.0218	0.0222
600	—	—	—	—	0.0176	.0290	0.0180	0.0295	—	—	0.0184	0.0187
750	—	—	—	—	0.0141	.0232	0.0144	0.0236	—	—	0.0145	0.0148
1000	—	—	—	—	0.0106	.0174	0.0108	0.0177	—	—	0.0109	0.0111
1250	—	—	—	—	0.00846	.0139	0.00863	0.0142	—	—	0.00871	0.00888
1500	—	—	—	—	0.00705	.0116	0.00719	0.0118	—	—	0.00726	0.00740
1750	—	—	—	—	0.00604	.00992	0.00616	0.0101	—	—	0.00622	0.00634
2000	—	—	—	—	0.00529	.00869	0.00539	0.00885	—	—	0.00544	0.00555
2500	—	—	—	—	0.00427	.00702	0.00436	0.00715	—	—	0.00440	0.00448

dc Resistance

Based on the resistance-temperature coefficient of copper of 100 percent conductivity and of aluminum 61 percent conductivity (international annealed copper standard) at 25C and the formulas:

R_1 = Resistance at 25C
R_2 = Resistance at desired temp. T_2
T_1 = 25C

Copper

$$R_2 = R_1 \left[\frac{234.5 + T_2}{234.5 + T_1} \right]$$

Aluminum

$$R_2 = R_1 \left[\frac{228.1 + T_2}{228.1 + T_1} \right]$$

Example:
R dc at 75C for 4/0 AWG uncoated copper = 0.0509 x 1.193 = .0607 ohms/1000 ft.

PROGRAM OUTPUT

CALC. TITLE Ampacities of Cables in Trays CALC. NO 01-EC-ZA-300

SUBJECT PVNGS Unit 1 SHEET NO. 5951 of 5953

Resistance temperature correction factors

Copper Conductors

Table 1-4

Temp. C	0	1	2	3	4	5	6	7	8	9
0	.904	.908	.911	.915	.919	.923	.927	.931	.934	.938
10	.942	.946	.950	.954	.958	.961	.965	.969	.973	.977
20	.981	.985	.988	.992	.996	1.000	1.004	1.008	1.012	1.015
30	1.019	1.023	1.027	1.031	1.035	1.039	1.042	1.046	1.050	1.054
40	1.058	1.062	1.066	1.069	1.073	1.077	1.081	1.085	1.089	1.092
50	1.096	1.100	1.104	1.108	1.111	1.115	1.119	1.123	1.127	1.131
60	1.135	1.139	1.143	1.146	1.150	1.154	1.158	1.162	1.166	1.170
70	1.173	1.177	1.181	1.185	1.189	1.193	1.197	1.200	1.204	1.208
80	1.212	1.216	1.220	1.224	1.227	1.231	1.235	1.239	1.243	1.247
90	1.250	1.254	1.258	1.262	1.266	1.270	1.274	1.277	1.281	1.285
100	1.289	1.293	1.297	1.300	1.304	1.308	1.312	1.316	1.320	1.324
110	1.328	1.331	1.335	1.339	1.343	1.347	1.351	1.354	1.358	1.362
120	1.366	1.370	1.374	1.378	1.381	1.385	1.389	1.393	1.397	1.400
130	1.405	1.408	1.412	1.416	1.420	1.424	1.428	1.432	1.435	1.439
140	1.443	1.447	1.451	1.455	1.459	1.462	1.466	1.470	1.474	1.478
150	1.482	1.480	1.489	1.493	1.497	1.500	1.505	1.509	1.513	1.516

Aluminum Conductors

Temp. C	0	1	2	3	4	5	6	7	8	9
0	.901	.905	.909	.913	.917	.921	.925	.928	.932	936
10	.940	.944	.948	.952	.956	.960	.964	.968	.972	.976
20	.980	.984	.988	.992	.996	1.000	1.004	1.008	1.012	1.016
30	1.020	1.024	1.028	1.032	1.036	1.040	1.044	1.048	1.052	1.056
40	1.060	1.064	1.068	1.072	1.076	1.080	1.084	1.088	1.092	1.096
50	1.100	1.104	1.108	1.112	1.116	1.120	1.124	1.128	1.132	1.136
60	1.140	1.144	1.148	1.152	1.156	1.160	1.164	1.168	1.172	1.176
70	1.180	1.184	1.187	1.191	1.195	1.199	1.203	1.207	1.211	1.215
80	1.219	1.223	1.227	1.231	1.235	1.239	1.243	1.246	1.250	1 254
90	1.258	1.262	1.266	1.270	1.274	1.278	1.281	1.285	1.289	1.293
100	1.297	1.301	1.304	1.308	1.311	1.315	1.319	1.324	1.328	1.332
110	1.336	1.340	1.343	1.347	1.351	1.355	1.359	1.362	1.366	1.370
120	1.374	1.378	1.381	1.385	1.389	1.393	1.397	1.401	1.405	1.409
130	1.413	1.417	1.420	1.424	1.428	1.432	1.436	1.440	1.444	1.448
140	1.452	1.456	1.459	1.463	1.467	1.471	1.475	1.479	1.483	1.487
150	1.491	1.495	1.498	1.502	1.506	1.510	1.514	1.518	1.522	1.526

To determine effective 60-Hertz ac resistance, multiply dc resistance values corrected for proper temperature, by the ac/dc resistance ratio given below. These apply to the following specific conditions.

Use Columns 1 and 2 for:

(a) Single-conductor non-metallic sheathed cables — in air or non-metallic conduit.

(b) Single-conductor metallic-sheathed cables with sheaths insulated — in air or separate non-metallic conduits.

(c) Multiple-conductor non-metallic sheathed cables — in air or non-metallic conduit.

NOTE: Columns 1 and 2 include skin effect only. For close spacing such as multi-conductor cables or several cables in the same conduit, there will be an additional apparent resistance due to proximity loss.

This varies with spacing (insulation thickness) but for most purposes can be neglected without serious error.

Use Column 3 for:

(a) Multiple-conductor metallic-sheathed cable.

(b) Multiple-conductor non-metallic sheathed cables in metal conduit.

(c) Two or more single-conductor non-metallic sheathed cables in same metallic conduit.

ac/dc resistance ratios for copper and aluminum conductors 60 Hertz (65C)

Table 1-5

Conductor Size AWG or MCM	1 Standard Conductor		2 Segmental Conductor		3 All Strandings	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum
Up to 3	1.000	1.000	—	—	1.00	1.00
2 and 1	1.000	1.000	—	—	1.01	1.00
0	1.001	1.000	—	—	1.02	1.00
00	1.001	1.001	—	—	1.03	1.00
000	1.002	1.001	—	—	1.04	1.01
0000	1.004	1.001	—	—	1.05	1.01
250	1.005	1.002	—	—	1.06	1.02
300	1.006	1.003	—	—	1.07	1.02
350	1.009	1.004	—	—	1.08	1.03
400	1.011	1.005	—	—	1.10	1.04
500	1.018	1.007	—	—	1.13	1.06
600	1.025	1.010	—	—	1.16	1.08
700	1.034	1.013	—	—	1.19	1.11
750	1.039	1.015	—	—	1.21	1.12
800	1.044	1.017	—	—	—	1.14
1000	1.067	1.026	1.010	1.005	—	1.19
1250	1.102	1.040	1.018	1.008	—	1.27
1500	1.142	1.058	1.028	1.012	—	—
1750	1.185	1.079	1.038	1.016	—	—
2000	1.233	1.100	1.052	1.020	—	—
2500	1.326	1.142	1.078	1.028	—	—

Calculate ampacity at other frequencies as follows:

1) Determine ac/dc ratio at required frequency from Table 1-7 after calculating value of B and K. By formula:

$$B = \sqrt{\frac{f}{R_{dc}}} \quad \text{and} \quad K = \frac{D_c}{S}$$

where f = frequency, R_{dc} = dc resistance, ohms /1000 ft. Dc = conductor diameter, S = axial spacing of conductors in inches.

2) Derating factor = $\sqrt{\dfrac{\text{ac/dc ratio at 60 Hz}}{\text{ac/dc ratio at f}}}$

3) Ampacity equals 60 Hertz ampacity multiplied by the derating factor.

PROGRAM OUTPUT

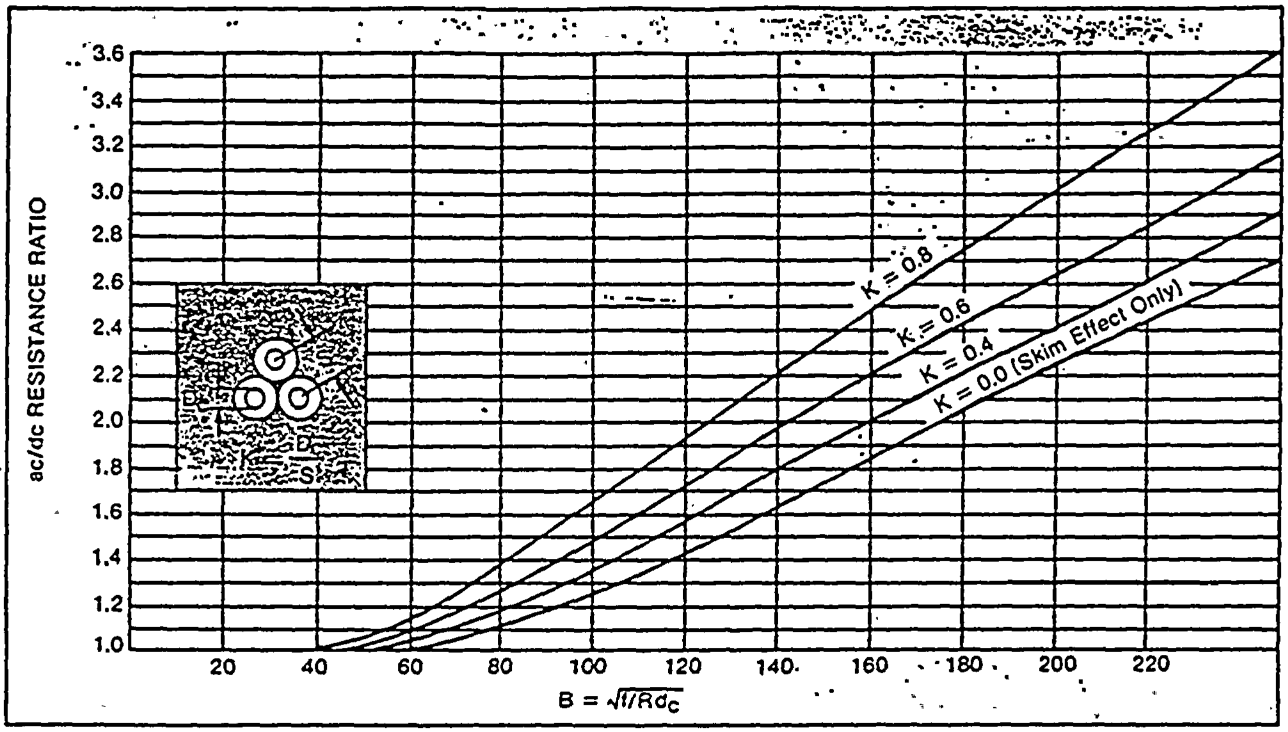
CALC. TITLE Ampacities of Cables in Trays   CALC. NO 01-EC-ZA-300

SUBJECT PVNGS Unit 1   SHEET NO. 5953 of 5953

Copper conductor resistance and ampacities at high frequencies

Table 1-7

Skin and Proximity Effects Solid and Concentric Stranded Round Conductors



Conductor resistance and ampacities at high frequencies

600 Volt Rubber-Neoprene Cables— Minimum triangular spacing in air or nonmetallic conduit   Table 1-6

Conductor Size	Conductor Diameter	Cable Diameter	K	D-C Res. 75C	400 Hertz B	400 Hertz AC/DC	Ampacity Derating Factor*	800 Hertz B	800 Hertz AC/DC	Ampacity Derating Factor*
AWG or MCM	Inches	Inches	Stranded Copper							
14	0.073	0.21	0.35	3.14	11.3	1.00	1.00	16.0	1.00	1.00
12	.092	.23	.40	1.97	14.3	1.00	1.00	20.2	1.00	1.00
10	.116	.25	.47	1.24	18.0	1.00	1.00	25.4	1.00	1.00
8	.146	.32	.46	0.780	22.7	1.00	1.00	32.0	1.00	1.00
6	.184	.39	.48	.490	28.6	1.00	1.00	40.5	1.00	1.00
4	.232	.44	.53	.310	36.0	1.00	1.00	51.0	1.05	0.98
2	.292	.50	.59	.194	45.4	1.03	.98	64.4	1.12	.94
1	.332	.61	.55	.154	51.0	1.05	.98	72.2	1.16	.93
1/0	.373	.65	.58	.122	57.4	1.08	.96	81	1.25	.89
2/0	.418	.69	.61	.097	64.5	1.15	.93	91	1.40	.84
3/0	.470	.75	.63	.0767	72.3	1.22	.90	102	1.53	.81
4/0	.528	.81	.65	.0608	81.4	1.33	.87	115	1.70	.77
250	.575	.92	.63	.0515	88.1	1.40	.84	125	1.82	.74
350	.681	1.08	.63	.0368	105	1.56	.80	148	2.05	.70
500	.813	1.16	.70	.0258	125	1.90	.72	177	2.54	.63
750	.998	1.38	.73	.0172	153	2.30	.66	216	3.06	.57
1000	1.152	1.54	.75	.0129	177	2.60	.62	249	3.44	.54

INFORMATION PURSUANT TO 10CFR50.54(f) REGARDING ADEQUACY AND AVAILABILITY OF DESIGN BASES INFORMATION

Table of Contents

Executive Summary

South Texas has a strong commitment and has communicated clear management expectations for maintaining the plant configuration and operating the plant in accordance with the design bases. South Texas has a unique construction and operating history, including a number of activities that provided emphasis on understanding, assessing, and capturing the design bases of the plant. This emphasis has continued into the operation of the plant. Details provided below form the basis for our belief that the plant has been, is now, and will continue to be, maintained and operated in accordance with established design bases. These activities also support our conclusion that it is not necessary to initiate an overall design basis reconstitution at South Texas.

Overview

This response to the NRC request for information covers a series of complex and extensive topics in a concise manner. Summary descriptions of current processes and programs are provided in parts (a) and (d). Parts (b) and (c) describe historical as well as current information that provides the rationale requested. This response is not intended to be a comprehensive description of all the design and configuration controls, corrective actions, nor oversight activities. It is the intent of this response to show that South Texas has a strong history of management control and oversight and to provide our rationale for concluding that there is reasonable assurance that South Texas is operated and maintained within the design bases. While the Executive Summary provides a high-level overview of our response, part (e) provides a summary and conclusion for the information provided in parts (a) - (d).

This response describes "snapshots" of many processes and programs that have evolved over time and does not attempt to describe their evolution; nor are the descriptions considered to be commitments. Some of the activities were performed by oversight organizations, some by independent third-parties, and others by line organizations. NRC inspection activities are also included in the discussion where they directly relate to a particular activity discussed.

The following paragraphs outline in summary form the major elements of our processes and programs that will be described in more detail later in this response.

Engineering Assurance

Many of the assessments described are the product of the South Texas Engineering Assurance Program. Some background on this program is appropriate. South Texas began an Engineering Assurance function during the construction phase to perform independent, third-party, real-time reviews of the engineering work performed by Bechtel and other contractors. These assessments were defined as a review of practices, processes and products to determine if they were consistent with the design bases and operating parameters, and were achieving the desired results. South Texas continued this Engineering Assurance function for revisions and modifications to plant design after commercial operation began. The Engineering Assurance assessment objectives included reviews to:

- Provide confidence that the technical adequacy of the plant is being maintained,
- Identify programmatic strengths and weaknesses, and
- Confirm that the plant design and licensing bases are maintained.

Today, this group is referred to as Engineering Quality in the Quality Department. The department is organized to provide independent oversight along the site functional areas of engineering, operations, maintenance, plant support, procurement and nondestructive examination. The Independent Safety Engineering function is distributed among each of these groups as appropriate. Each of these groups' respective responsibilities include oversight of plant programs and procedures. Confirmation of adequate design and operating bases is emphasized during audits, surveillances, assessments, monitoring, inspections and reviews. When problems are identified, they are processed for resolution in accordance with the corrective action process.

Design/Configuration Control

At South Texas, configuration management requirements are incorporated in procedures governing modification of configured items, drawing and design control, procurement, operations, maintenance, supplier information control, records management, licensing document control, training simulator configuration, spare parts identification and control, and nonconformance disposition and control. Changes to structures, systems, or components are evaluated and comply with the requirements of the Operating License and the Updated FSAR or regulatory approval is obtained prior to implementation. Any alteration with regard to design bases or erected configuration is reflected in the appropriate controlled documentation. Changes to design documents are made through a controlled review and approval process prior to issuance for use.

The processes that may result in a facility change include evaluation of nonconforming conditions, changing plant design, and changing plant procedures. Each of these processes requires a 10CFR50.59 evaluation, which in turn, requires a review of the UFSAR and other docketed licensing information. When appropriate, changes to the safety analysis report and other licensing basis documents may then be initiated. The procedure for changes to licensing basis documents and amendments to the operating license also imposes the requirements for the biennial update of the UFSAR in accordance with 10CFR50.71(e).

Configuration/Performance

South Texas has a unique construction and operating history, including a number of activities that provided emphasis on understanding, assessing, and capturing the design bases of the plant. Extensive efforts were undertaken to confirm that the as-built configuration of the plant conformed to the established design bases. These efforts have been carried through to the

operations phase, including real-time engineering involvement in modification installation activities, focused system engineering dedication to system health, operations and maintenance personnel sensitivity to configuration management/control needs, management oversight and aggressive self-assessment, and independent oversight. In concert, these efforts provide a high level of confidence that plant configuration and performance are maintained in accordance with established design bases.

Plant Procedures

The process steps for the preparation, revision, review, and approval of plant procedures are the same for the generation of new procedures and the revision of existing procedures. These steps include completion of a license compliance review and a technical review checklist. The technical review checklist includes a review of design documents to show that the procedure implements design requirements or that the procedure does not conflict with design requirements. The license compliance review requires consideration of requirements in the Final Safety Analysis Report, Technical Specifications, and design documents, among others. South Texas has had aggressive independent oversight, self-assessments, and inspections that provide the basis for our conclusion that there is reasonable assurance that the South Texas design bases have been translated into the operating, maintenance, and testing procedures.

Conduct of Safety System Functional Assessments

South Texas took the initiative early in plant operation to conduct vertical slice team assessments in order to confirm that certain systems were designed, constructed, operated, and maintained in accordance with the design bases. These SSFA teams were staffed with South Texas personnel who were well-qualified to conduct such in-depth assessments and were supplemented with consultants known for their expertise, as appropriate. The scope and vertical slice techniques employed in the SSFA's were modeled after those used by the NRC in their Safety System Functional Inspections (SSFIs). The fundamental principles of SSFI techniques include a deep, vertical-slice review and team interactions, which were provided through daily meetings of the multi-disciplinary review team. These assessments and their results are described in several places in the response.

Independent Oversight Activities

South Texas confirms its compliance with its Quality Assurance Program and 10CFR50 Appendix B requirements through many independent oversight activities (e.g., QA audits, surveillances, assessments). The results of some of these activities are very briefly summarized in several places in the following pages. The summaries are not intended to be exhaustive. The purpose is to demonstrate that South Texas is committed to performing the required oversight activities and that when problems are found, they are addressed in accordance with the corrective action program or, historically, with other established resolution processes

NRC Inspections

References are made to NRC inspection results only as confirmation of South Texas actions, supplementing the findings of the South Texas self-assessment activities.

Corrective Action Program

South Texas has implemented a corrective action process that is the single, integrated process for identification, resolution, and tracking of conditions station-wide, from normal work orders to significant conditions adverse to quality. Conditions identified in this process can be directed to a number of interfacing processes, including maintenance, plant procedure changes, shutdown risk assessment, design change implementation, vendor technical information, design change packages, changes to licensing basis documents, and justification for continued operation. The program is widely accepted and used by plant personnel.

Overall Effectiveness

Past and current processes, and aggressive management oversight, self-assessment, and independent oversight activities provide reasonable assurance that the configuration and performance of South Texas are consistent with the design bases. The review of the findings and actions from the various audits, assessments, and inspections discussed in this response supports the conclusion that current oversight, assessment, audit, surveillance, and corrective action processes provide a reasonable level of confidence in the design and configuration control processes.

Historical Perspective

The following brief summary describes some of the key events in the history of South Texas:

1975	Construction permit issued
1981	Decision made to change the architect/engineering firm responsible for the design of the plant
1981 - 1984	Comprehensive transition process; detailed re-evaluation of design bases; aggressive utility oversight of design process; captured design bases information
1984 - 1987	Engineering Assurance program provided independent vertical slice evaluations of the architect/engineer's work; Pre-Construction Appraisal Team Inspection, Limited Readiness Review Audit Program, and Plant Completion Verification Program were conducted
1987	Technical Specification certification performed to support issuance of low-power license

1987	Technical Specifications issued based on Westinghouse Standard Technical Specifications
1988	Certification performed for combined Technical Specifications
1987, 1988	Operating licenses issued; Engineering Assurance program carried into plant operational phase
1989	Final Safety Analysis Report updated and resubmitted as the Updated Final Safety Analysis Report; revisions submitted in 1990, 1991, 1992, 1994, and 1996
1993 - 1994	Aggressive actions taken to resolve issues and improve material condition during extended shutdown
1996	Began comprehensive re-review of the Updated Final Safety Analysis Report to provide a higher level of confidence that the document is current and accurate
1996	Most recent Engineering self-assessment performed in lieu of NRC Engineering Team Inspection; included vertical slice techniques

A graphical presentation of pertinent events described in this response is provided at the end of the response to assist in establishing a chronological perspective.

Response to Information Request (a)

(a) Description of engineering design and configuration control processes, including those that implement 10 CFR 50.59, 10 CFR 50.71(e), and Appendix B to 10 CFR Part 50

1.0 Introduction

A brief summary of the current South Texas engineering design and configuration control processes is provided, followed by a brief description of the current programs designed to ensure compliance with 10CFR50.59, 10CFR50.71(e), and 10CFR50 Appendix B. The comprehensive process to control and maintain the design bases and configuration described below is an integral part of the plant procedures.

2.0 Engineering Design and Configuration Control Processes

The purpose of the South Texas configuration management program is to ensure that plant physical and functional characteristics conform to the approved design and are correctly reflected in technical, procedural, and training documents. The program includes items and activities which are necessary to ensure that physical and functional characteristics are reflected correctly in field hardware, documentation, repair parts, and training.

The configuration management program is designed to ensure that configuration management requirements are incorporated in procedures, activities, and practices associated with processes that include modification of configured items, drawing and design control, procurement, operations, maintenance, supplier information control, records management, licensing document control, training simulator configuration, spare parts identification and control, and nonconformance disposition and control.

2.1 Engineering Design Control Process

The objectives of the South Texas design control process are to ensure that:

- Changes to structures, systems, or components are properly evaluated and that they comply with the requirements of the Operating License and the Updated FSAR or that appropriate evaluations or regulatory approvals are obtained prior to implementation.

- Alterations with regard to design bases or erected configuration are reflected in the appropriate controlled documentation.

- Changes to design documents are made through a controlled review and approval process prior to issuance for use.

The design control process applies to activities which involve temporary or permanent modification to existing structures, systems, or components that are the subject of the design bases. These activities may include, but are not limited to, the following:

- Modification control program
- Temporary modifications program
- Setpoint changes made per approved procedures
- Disposition of "use-as-is" and "repair" nonconforming conditions
- Specified technical and quality requirements for structures, systems, or components which are incorporated into procurement-related documents
- Development of or modification to computer programs (software) that provide automatic control of any operating plant system or provide an indication that is utilized by plant operators for taking manual actions.

The design control process meets the requirements of Regulatory Guide 1.64, Rev. 2, as noted in UFSAR Table 3.12-1 for structures, systems, and components that are classified as safety-related and for those that involve the following:

- Fire protection system
- Radwaste systems
- Post-accident monitoring system
- Seismic II/I considerations
- Selected changes to environmental/effluent monitoring and the emergency preparedness facility as committed to the regulatory agency.

Changes from specified design inputs and the reasons for the changes are identified, approved, documented, and controlled by the design control program. Applicable design inputs include items in ANSI N45.2.11, Section 3.2, such as design bases, regulatory requirements, quality levels, acceptance standards, design criteria, and codes and standards, and these are identified, documented, and their selection is reviewed and approved.

The purpose of the various procedures is to ensure that applicable design inputs are correctly translated into specifications, drawings, procedures, and instructions. Appropriate quality standards are identified and documented, and their selection is reviewed and approved. Associated documentation is maintained as records in the records management system.

The extent of required design verification is a function of the importance to safety of the item under consideration and the complexity of the design. Where changes to previously verified designs have been made, design verification is required for the changes, including evaluation of the effects of the changes on the overall design.

Design control measures commensurate with those applied to the original design also control changes to approved design documents. The control measures ensure that the impact of a design change is carefully considered, that required actions are identified, and that information regarding the change is transmitted to affected persons and organizations.

The design control program is put into effect through implementation of the procedures that govern the control of design documents and associated design-related activities, such as the:

- Design change package procedure
- Design change implementation procedure
- Temporary modifications procedure
- Plant modifications procedure
- Design change functional testing procedure
- Condition report engineering evaluation program.

2.2 Configuration Control Processes

The configuration control processes are designed to ensure that the physical station configuration is in a known or controlled state as documented or authorized in the station configuration documents. The design change process interfaces with the configuration control processes by establishing authorization for changes to the physical station configuration not already authorized in configuration documents. The configuration control processes include the work control process, the operational control processes, and the operating and test procedures.

The design control and configuration control processes both use the corrective action program electronic database to track and ensure completion of activities related to the development of design enhancements/changes to the plant and completion of the associated activities; and to ensure that the impacted design bases documents and associated process procedures are updated to reflect these changes. The database is structured such that the controlling condition report cannot be closed until the associated actions have been completed.

2.2.1 Procedures

Maintenance, testing, and operation of systems and components are performed in accordance with approved procedures which are designed to ensure that the configuration at any point in the procedure is known and is acceptable. Changes to plant configuration authorized by the design change process are reviewed for potential impact to plant procedures for maintenance, testing and operation by the organizations which are responsible for these procedures. Changes to procedures which are required as a result of a design change are implemented before the design change is considered completed.

2.2.2 Operations

The operational control processes complement the operating and test procedures to maintain configuration control. These processes include the equipment clearance order process, which establishes controls for removing systems or components from service for maintenance or other purposes. In addition, the locked component program controls configuration of components normally locked.

Administrative controls govern adherence to written instructions in performing activities and establish requirements for independently verifying activities that affect the alignment or status of systems and components. The purpose of these controls is to ensure that plant configuration is understood and maintained by operating personnel.

The operability assessment system is an aid in maintaining proper configuration and is used to track Technical Specifications equipment that is not capable of performing its design function. This is a computer database maintained by the main control room unit supervisor. Operations uses this system to track compliance with Technical Specification limiting conditions for operation.

2.2.3 Maintenance

Performing maintenance on systems, structures, and components usually involves disassembly or otherwise altering the approved configuration of the component. The work control process includes steps requiring that the configuration of components under maintenance is tracked and is restored to an authorized state prior to placing the component in service. The work control process invokes independent verification for ensuring configuration is properly restored after maintenance activities on equipment and components. Selective independent inspections are also performed, which provide added confidence.

Temporary configuration changes to permanent plant equipment during maintenance and troubleshooting are controlled by procedure. This procedure requires tracking configuration changes performed in support of a maintenance or troubleshooting activity, such as switch or valve manipulations; lifted leads; and the installation and removal of electrical or mechanical jumpers, blind flanges, and fuses. Activities involving removal, replacement, and installation of fuses are governed by this procedure. If components are restored to operation with temporary

configuration changes still installed, procedures require approving and documenting such changes with temporary modifications.

3.0 Implementation of 10CFR50.59 Requirements

The South Texas 10CFR50.59 evaluation procedure defines and controls the program for evaluating procedure changes, design changes, tests, and experiments in accordance with 10CFR50.59 requirements. The evaluations determine if these actions involve an unreviewed safety question or changes to the Technical Specifications.

The procedure is applicable to:

- Permanent and temporary changes to the facility, including use-as-is and repair disposition of non-conforming conditions
- Changes to procedures as described in the Safety Analysis Report, including licensing commitments
- Tests and experiments
- Updated Final Safety Analysis Report (UFSAR) Change Notices
- Operations Quality Assurance Plan

The procedure provides detailed definitions of the key terms associated with the performance of 10CFR50.59 evaluations, and broadly defines the safety analysis report to include most docketed information in addition to the UFSAR itself. It also requires consideration of an appropriate interdiscipline coordination review.

If an evaluation determines that an unreviewed safety question does exist, the procedure prohibits implementation of the proposed change without prior NRC approval. If the evaluation identifies an unreviewed safety question with an existing condition, the procedure directs action to generate a Justification for Continued Operation, or declare the affected structure, system, or component inoperable and take the appropriate action.

The Plant Operations Review Committee (PORC) reviews proposed changes, tests, and experiments for which an unreviewed safety question evaluation is prepared to determine if an unreviewed safety question is involved, if the evaluation basis is adequate, and if the proposed action is safe. The PORC recommends approval or disapproval to the plant manager.

The plant manager approves or disapproves changes, tests, and experiments for which an unreviewed safety question evaluation is prepared.

The Nuclear Safety Review Board (NSRB) reviews approved unreviewed safety question evaluations for changes, tests, and experiments to verify that they do not constitute an unreviewed safety question. The NSRB also reviews proposed changes, tests, and experiments which do involve an unreviewed safety question prior to submittal to the NRC.

3.1 Changes to Facility

The processes which may result in a facility change include evaluation of nonconforming conditions, changing plant design, and changing plant procedures. Changing the plant design also includes temporary design changes. Each of the process procedures that may result in a facility change requires a 10CFR50.59 evaluation when appropriate.

3.2 Changes to Procedures

The station process governing the preparation, review, approval, and revision of plant procedures requires personnel performing procedure writing and revision activities to perform a license compliance review, if appropriate. The license compliance review procedure provides guidelines for considering applicability of 10CFR50.59 to the proposed procedure or procedure revision. A qualified reviewer (defined by the procedure) is required to review and sign the compliance form. If this review determines that the proposed procedure or revision is a change to the facility or procedures as described in the SAR, an evaluation is performed using the 10CFR50.59 evaluation process described above. If that evaluation determines that the procedure involves an unreviewed safety question, then the procedure cannot be approved for plant use until a license amendment is approved.

3.3 Tests or Experiments

Conduct of tests or experiments is controlled by plant procedures which require a license compliance review.

4.0 Implementation of 10CFR50.71(e) Requirements

As described in Section 3, proposed changes are required to be evaluated to determine if the proposed change represents a change to the facility as described by the safety analysis report. This evaluation requires a review of the UFSAR and other docketed licensing information. When appropriate, changes to the safety analysis report and other licensing basis documents may then be initiated in accordance with guidance in the procedure for changes to licensing basis documents and amendments to the operating license.

The procedure for changes to licensing basis documents and amendments to the operating license also imposes the requirements for the biennial update of the UFSAR in accordance with 10CFR50.71(e). This procedure provides for maintaining the configuration of the UFSAR in the interim period between updates.

5.0 Implementation of 10CFR50 Appendix B Requirements

The South Texas Quality Assurance Program is prescribed in the Operations Quality Assurance Plan (OQAP). This licensing basis document provides direction for the performance of station activities in conformance with the applicable requirements of 10CFR50 Appendix B, other applicable regulations and industry standards as specified in Chapter 2.0 of the OQAP, plus those NRC Regulatory Guides that South Texas has committed to in UFSAR Table 3.12-1.

The OQAP describes the requirement to maintain plant configuration and documentation consistent with current, approved design bases. South Texas maintains continuous oversight of these program characteristics through daily personnel self-checking, organizational self-assessment, process checks and balances (e.g., independent reviews/verifications), and management and independent oversight of work activities and products.

The effectiveness of those oversight activities is also regularly assessed through independent oversight (e.g., Quality audits, assessments, evaluations, monitoring, inspections), Plant Operations Review Committee, Nuclear Safety Review Board, and through external assessments.

...

Response to Information Request (b)

(b) Rationale for concluding that design bases requirements are translated into operating, maintenance, and testing procedures

1.0 Introduction

South Texas has had a rigorous process for preparing and revising operating, maintenance, and testing procedures since the early 1980s when initial plant procedural development began prior to issuance of the operating licenses. This process has evolved and has been the focus of many audits, surveillances, assessments, and inspections of the process, process controls, and the procedures themselves. South Texas has taken the initiative to conduct Safety System Functional Assessments (SSFAs), which are vertical slice assessments performed to provide a high level of confidence that the plant design bases are accurately captured, controlled, and reflected in the operating, maintenance, and testing procedures. Also included are various other self-assessments which are in addition to the required 10CFR50 Appendix B audit program and NRC inspection activities. The following response to NRC request (b) provides a high-level description of some of the more significant of these audits, inspections and assessments.

It is important to recognize that these audits, assessments, and inspections have identified issues that required corrective action. When an issue is identified, it is evaluated in accordance with the corrective action program and appropriate actions are identified, assigned to responsible individuals, and tracked. Some of the more significant actions taken are described in the following response.

2.0 Initial Procedure Development

In April 1983, the initial procedure was defined for the preparation, review, approval, revision, correction, and deletion of permanent and temporary plant operating, maintenance, and testing procedures. This procedure established the method by which commitments in FSAR Section 13.5.1.2 were fulfilled.

New plant procedures and revisions thereto were required to have a license compliance review prior to the procedure review process. Individuals preparing or reviewing license compliance reviews consider the following:

- Final Safety Analysis Report
- Technical Specifications
- NRC Safety Evaluation Reports
- NRC Regulatory Guides and NUREGs
- NRC I&E Bulletins, Notices, and Generic Letters
- Code of Federal Regulations
- Industry codes and standards
- Significant industry events
- Plant policies, programs, and procedures

- Drawings, vendor manuals, and other design documents
- Licensing commitments

In addition to the license compliance review, a Technical Review Checklist was created just prior to the Unit 1 full power operating license that specifically required consideration of safety limits, setpoints, equations, operability limits, and acceptance criteria listed in the Technical Specifications, FSAR, or other licensing documents.

The procedure process also had a feedback mechanism for continuous identification and correction of problems. The program required procedure problems to be documented through the station problem reporting process (now superseded by the condition reporting process), evaluated, and corrected.

3.0 Procedure Control Process

The steps of the process for the preparation, revision, review, and approval of the procedures contained in the Plant Procedure Manual are the same for the generation of new procedures or revision of existing procedures. These steps include requirements for a license compliance review, a technical review checklist, a surveillance procedure checklist, surveillance procedure walkthrough for new surveillance procedures, and identification of required training. The technical review checklist requires the preparer to review design documents to show that the procedure implements design requirements or that the procedure does not conflict with design requirements.

In addition to a technical review, an interdisciplinary review is performed, as appropriate. Procedures are reviewed by the appropriate level of management and may include review by the PORC and approval by the plant manager.

Changes to the design bases are reflected in procedures through procedure changes initiated as part of the design change process. Design change packages (DCPs) are reviewed by cognizant reviewers from potentially impacted organizations to evaluate whether any actions such as procedure changes are required as a result of the design change. These reviews are documented prior to approval of DCPs for modifications. Included in the review is a determination whether the associated procedure change needs to be made before the modified component is returned to service. When the design change is implemented, the procedure change is required to be completed before the final closure of the design change.

4.0 Procedure Control Process Effectiveness

4.1 Safety System Functional Assessments

Since 1989, South Texas has conducted four safety system functional assessments (SSFAs) that have included assessment of the consistency of the operations, maintenance, and testing procedures with the design bases. The SSFAs are vertical slice assessments based on the NRC Safety System Functional Inspections (SSFIs).

4.1.1 Essential Cooling Water System

During October - December 1989, South Texas conducted an SSFA on the essential cooling water (ECW) system. This was a performance-based assessment using vertical slice techniques and criteria as detailed in the NRC Inspection Manual Chapter 2515, including an NRC-type schedule of activities. The scope of the assessment included certain safety-related systems which support ECW operation such as the essential cooling pond, ECW intake structure ventilation, and AC power supply systems. The scope also included the safety-related components supplied by the ECW system: component cooling water heat exchangers, standby diesel generator cooling heat exchangers, and essential chillers. The assessment involved review of a substantial number of design, operations, and maintenance-related documents; walkdowns of the system and interfacing equipment; and interviews with engineering, operations, maintenance, and management personnel.

An assessment plan was developed which conformed to the NRC methodology for performing SSFIs and provided a framework to answer the following questions:

How is the system operated compared with how it was designed to operate?

Are system components and components of essential support systems properly maintained?

Does post-modification testing confirm the readiness of the system?

Does surveillance testing confirm the readiness of the system if called upon? Do test acceptance criteria accurately reflect the design bases?

Are management control programs effective to insure that the system will function on demand?

The assessment discovered weaknesses related to system operation at low ECW temperatures, draining of standby trains through low-point drains, and operating with two trains cross-connected. Although weaknesses were noted, an evaluation at the time demonstrated that the system would perform its safety function. Procedure changes and additional operator actions were introduced to provide more reliable system operation at low ECW temperatures. The low point drain valves were danger tagged in the closed position in both units and the valve line-up was changed in the procedure. Procedure changes were incorporated to prohibit use of the cross-connect lines.

4.1.2 Auxiliary Feedwater System

During August - October 1991, South Texas conducted an SSFA on the auxiliary feedwater system. Additional detail is provided in the response to NRC request (c), Section 4.1.2, below. The team found that the operating, maintenance, and surveillance testing procedures were adequate to implement the auxiliary feedwater system design.

4.1.3 Essential Chilled Water System

In early 1993, South Texas conducted an SSFA on the essential chilled water system design, procedures, work history, and corrective actions that included the following objectives:

Confirm that the essential chilled water system can perform its intended design basis functions on demand.

Confirm the technical adequacy of operations, maintenance, and testing procedures.

The conclusions of the team pertinent to this discussion addressed a weakness in incorporating actions for low essential cooling water temperature operation into the Emergency Operating Procedures. This was determined not to be a generic concern with EOP preparation and was ultimately resolved by a plant modification.

4.1.4 Safety Injection System

In June - October 1993, South Texas conducted an SSFA on the safety injection system to assess the operational readiness of the system to perform its intended safety function, and to find causes of potential system unavailability. The scope of the assessment included the safety injection system and those interfacing systems that are required to support its primary and secondary functions. The assessment addressed the following specific functional areas:

Determine if the plant operating procedures assure satisfactory system performance for normal and accident conditions and assess whether operations personnel can effectively execute the procedures.

Determine if maintenance performed on the system or component is adequate to ensure that the system or component will perform its desired safety function.

Determine if the periodic tests performed on the system or components verify operability per Technical Specification requirements and that applicable commitments in the current licensing basis are being met.

The assessment team concluded that the safety injection system is being maintained in a condition that is satisfactory to support its intended function on demand, and the surveillance tests performed on the system meet Technical Specification requirements and adequately demonstrate system operability.

4.2 Specific System Procedure Reviews

4.2.1 Turbine-Driven Auxiliary Feedwater Pumps

In early 1993, a review of the turbine-driven auxiliary feedwater pump procedures, work history, and corrective actions was conducted. One objective of the assessment was to confirm the technical adequacy of operations, maintenance, and testing procedures.

The review team found that the procedures did not always clearly or adequately reflect requirements or recommendations for operation, testing, or maintenance of the AFW pumps. The issues associated with this review were resolved in conjunction with the return to power operation following the 1993-1994 shutdown.

4.2.2 Standby Diesel Generators

A review of the standby diesel generator procedures, work history, and corrective actions was also conducted in early 1993, with a specific objective of confirming the technical adequacy of operations, maintenance, and testing procedures.

It was found that a procedure did not require maintaining the SDG room > 50°F, the minimum temperature at which the diesel auxiliaries are rated. It was later determined by South Texas and confirmed by the manufacturer that the standby diesel generator and its auxiliaries will operate in a room ambient condition of 8°F.

4.3 Operating Procedures

4.3.1 Operating Procedure Upgrade Program

In May 1989, South Texas initiated a long-term enhancement program for operating procedures in response to findings identified in the Unit 2 operational readiness review. The purpose of the program was to ensure that procedures were in compliance with the design bases and that procedures, drawings, physical plant configuration, and design bases agreed. The program was scheduled as a five-year effort which commenced with an immediate upgrade to the Emergency Operating Procedures (EOPs) to correct procedure nomenclature deficiencies. The long-term procedure upgrade program was divided in portions and prioritized with one group working to rewrite the EOPs to conform with the Westinghouse Owner's Group Emergency Response Guidelines, Revision 1A, and another group working to enhance off-normal and annunciator response procedures.

The method used to upgrade the procedures focused on a walkdown of the plant with a detailed comparison to the drawings. At the same time, completed modifications, outstanding feedbacks, station problem report corrective actions, and licensing commitments were incorporated into the plant procedures. Modifications that were in process or planning were listed as outstanding and a tracking system was created to facilitate continued real-time conformance. This real-time

information was then compared to the design basis documents, FSAR, the NRC safety evaluation reports, and Technical Specifications. A final verification of each procedure was performed to validate it either by walking the procedure down in the field or actual performance with drawings and procedures in hand.

The EOP upgrade was completed in 1991 and the remainder of the operations procedure upgrade program was completed in December 1993.

The NRC conducted an inspection of operating procedures in April 1995, which confirmed South Texas' confidence that the program had accomplished the desired objectives. Inspection Report 50-498/499/95-07 noted that previous NRC inspections had identified concerns with the EOPs, but during this inspection the NRC found that the reviewed procedures were of good quality, technically correct, and conformed to plant conditions.

4.3.2 Self-Assessments

During the period of November 1990 - February 1991, South Texas conducted a technical review of the Emergency Operating Procedures to verify their capability to aid plant operators in mitigating the consequences of an accident potentially affecting the health and safety of the public. Additionally, the procedures were reviewed for technical adequacy, accuracy, and human performance factors.

The overall evaluation of the procedure-operator interface indicated that the procedures were effective for the control of accidents described in the safety analysis report. The team did not identify any safety concerns.

In March 1995, the plant procedures controlled by Operations were evaluated against the criteria in the NRC Inspection Manual Procedure 42700. The assessment team was comprised of experienced personnel from Operations, Engineering, and Records Management. The team members assessed areas within their respective expertise. Each of the NRC criteria was evaluated for each group of procedures. The assessment concluded that the following inspection objectives in the NRC Inspection Manual were met for the procedures reviewed:

- Operations procedures are in accordance with regulatory requirements.
- Field changes and revisions to operations procedures were made in accordance with plant administrative procedures and Technical Specification requirements.
- The technical adequacy of operations procedures is consistent with the desired actions and modes of operations.

4.3.3 Independent Oversight

Seven QA audits, and many surveillances and reviews of the operating procedures have been conducted since 1989, with the combined specific objectives including determining if:

Operating procedures are technically adequate and are properly prepared, reviewed, approved, revised, controlled, and distributed.

Possible impacts due to design changes are properly assessed for the effect on Operations programs, procedures, and training.

Management enforces adherence to procedures, policies, and standards.

Components required to be locked in place are included in the locked component program and are properly positioned and locked to ensure proper equipment and system operation on demand.

Identified problems were processed for resolution in accordance with the corrective action process or other established resolution processes.

4.4 Maintenance Procedures

4.4.1 Engineering Assurance Assessment

During the period of October - December 1992, South Texas conducted an assessment using the vertical slice audit technique to evaluate maintenance activities. One assessment objective was to determine the adequacy of the program for preserving the plant design bases. Identified problems were processed for resolution in accordance with the corrective action process or other established resolution processes.

4.4.2 Independent Oversight

Six QA audits and many surveillances and procedure reviews have been conducted in the area of maintenance since August 1988. Assessed activities included maintenance procedure development and revision, with specific objectives that included:

Maintenance procedures and their revisions are properly prepared, reviewed, approved, and controlled.

Self-assessments are performed to evaluate the effectiveness and efficiency of maintenance policies, procedures, and programs. Problems, concerns, and improvement items are properly identified, documented, and corrected.

Maintenance evaluates its programs by comparison with the industry (INPO, NRC, other utilities, etc.) and develops actions to incorporate improvements.

A 1991 audit concluded that the maintenance procedures are technically adequate and controlled, and provide adequate detail to assure proper performance of the activity. The acceptance criteria are in conformance with the design bases and readily obtainable from an approved source.

The NRC conducted a Maintenance Team Inspection during January - March 1990.

4.5 Testing Procedures

Refer to the response to NRC request (c), Section 2.9, below for a description of the startup turnover and testing program and how the design bases were incorporated into that program. The following description addresses South Texas confidence in the testing programs that were implemented after startup testing.

4.5.1 Independent Oversight

After the startup test program was completed, independent oversight of testing changed focus to assess testing programs for plant surveillances, pump and valve IST, inservice inspections, system pressure, contaminated system leakage, snubbers, containment leakrate, nuclear air-cleaning systems filters, MOVs, and post-maintenance testing. Also included were preparation, review, approval, control, and distribution of testing procedures. Eight QA audits and many surveillances and reviews have been conducted to assess the ongoing testing programs.

To summarize the results of this oversight, it was concluded that South Texas testing procedures and performance were generally adequate and effective in satisfying established measures and acceptance criteria for confirming component/system functions and satisfying the Technical Specifications and design bases. Identified problems were processed for resolution in accordance with the corrective action process or other established resolution processes.

Two noteworthy improvement efforts that resulted from oversight activities included a 1990 setpoint verification program and a plant surveillance procedure enhancement project. The latter was in response to several internal deficiency documents, Licensee Event Reports, and NRC Notices of Violation. The project is described below.

5.0 Plant Surveillance Procedure Enhancement Project

5.1 Project Description

South Texas has conducted a surveillance procedure review and enhancement project to address deficiencies that were self-identified in the 1989-1991 time frame. The self-initiated review included consideration of the UFSAR, technical specifications, NRC Safety Evaluation Reports, and design basis documents. The review initially focused on the surveillance procedures for the Engineered Safety Features Actuation System and the Reactor Protection System and was expanded to include additional surveillance procedures. The review encompassed most of the scope of Generic Letter 96-01, which addresses the potential for deficiencies in testing of safety-

related logic circuits involving the reactor protection system, SDG load shedding and sequencing, and actuation logic for the engineered safety features system. Approximately 550 surveillance procedures have been reviewed in the course of the initiative and an estimated 16,000 man-hours have been expended.

5.2 Project Effectiveness

In late 1994, South Texas conducted a self-assessment of the Surveillance Procedure Enhancement Project. The first objective of the self-assessment was to determine if the surveillance procedures accurately implement the plant design bases. Another objective was to determine if the enhanced procedures adequately address the Technical Specification requirements and safety functions, and the intended function of the test could be accomplished. Improvements were implemented in controlling the surveillance procedure bases documents as a result of the assessment.

The assessment identified strengths in the program in that the enhanced procedures were technically correct, no LERs or station problem reports had been written against the enhanced procedures, technical bases documents were prepared for each procedure or family of procedures; and the bases documents were found to be technically accurate.

In April 1995, South Texas performed an assessment to review the actions taken by Operations to address the recommendations from the earlier assessment. Specific bases documents were also reviewed to determine how bases requirements were being documented. The team found that management oversight of the project had improved. There was a high level of confidence that the remaining procedures to be enhanced had been properly prioritized and recommendations were being addressed through increased management attention.

The NRC conducted an inspection of the surveillance procedure enhancement project in June 1995.

6.0 Conclusion

South Texas has a history of aggressive independent oversight activities, self-assessments, and inspections; some of the more significant of these activities were described above. These activities provide the basis for our conclusion that there is reasonable assurance that the South Texas design bases have been translated into the operating, maintenance, and testing procedures, and that the processes described in response to NRC request (a) above are accomplishing the intended function. Findings generated by these activities have been addressed in accordance with the corrective action program or other established resolution process at the time. The significant findings affecting translating the design bases into the procedures resulted in procedure upgrade projects. Reviews of the results of these projects indicate that the actions taken were successful. Self-assessments, independent oversight, and inspections in these areas are continuing and are recognized as essential contributors to continuous improvement. South Texas is committed to continue a philosophy of continuous improvement, in part through a program of management involvement, aggressive self-assessment, and independent oversight.

Response to Information Request (c)

(c) Rationale for concluding that system, structure, and component configuration and performance are consistent with the design bases

1.0 Introduction

In 1981, South Texas made an unprecedented decision to change architect/engineering firms responsible for the design of the station. One result was to locate a team of experienced utility nuclear plant design engineers in the architect/engineer's offices to oversee the design process, in addition to a team of engineers at the plant site. These engineers formed the core of the South Texas design engineering organization when design control was transferred to the utility. Also to ensure the design bases knowledge was retained, South Texas developed a set of Design Basis Documents to describe the design bases of key systems and provide a reference to the location of the design bases calculations, analysis and drawings.

South Texas was one of the last plants licensed and was able to apply many lessons learned from earlier plants. This included a program of aggressive design control independent assessment (i.e., audits, surveillances) to provided added assurance. These assessment activities identified issues regarding compliance with the design bases, and appropriate actions were taken to address the specific and generic issues. South Texas undertook major efforts when needed in response to issues identified, for example: a comprehensive plant re-labeling program, a review of the fuse list, development of a setpoint design basis document, vendor manual upgrades, Master Equipment Database upgrade, Master Parts List upgrade, and Surveillance Procedure Enhancement Project.

South Texas had an aggressive process to initially capture the design bases and has a strong commitment to maintaining and assessing the process. In cases where a design bases issue is identified, the issue is evaluated in accordance with the corrective action program and appropriate actions are identified, assigned to responsible individuals and tracked. Some of the more significant actions taken are described in the following response.

In addition to the required 10CFR50 Appendix B audit programs and NRC inspection activities, South Texas maintained an aggressive QA surveillance/review and QC inspection program, and created an Engineering Assurance program, which included vertical slice assessment activities, during construction to provide independent verification and assessment of the architect/engineer's work. Following issuance of the operating licenses, South Texas has had a process to control the design bases in accordance with the requirements of 10CFR50 Appendix B and 10CFR50.59. This process has been the subject of many audits, surveillances, reviews, inspections, and assessments, including a continuation of the Engineering Assurance process begun before the operating licenses were issued. The following response to NRC request (c) includes a high-level description of some of these activities.

2.0 Design Bases Translated into Plant Construction

Following is a description of significant evaluations performed during design and construction of South Texas, focusing on activities relevant to understanding, capturing, and ensuring compliance with the design bases. This description establishes South Texas' rationale for confidence that the design bases are accurately translated into the as-built plant.

2.1 Bechtel Transition Program

In September 1981, with plant completion at approximately 50%, Bechtel was retained by HL&P to replace Brown & Root as Architect/Engineer and Construction Manager. In order to successfully execute its responsibilities as Engineer and Construction Manager for STP; it was necessary for Bechtel to determine the state of completion and the adequacy of work performed by Brown & Root. The "transition program" was developed to achieve this end.

The engineering design adequacy/status review was accomplished through a series of approximately 180 transition work packages, each one covering a specific system, building, or topic. Bechtel engineering evaluated the design assumptions and methods of analysis; determined whether the design satisfied the applicable criteria and addressed the necessary technical requirements; reviewed design interfaces with vendor-supplied equipment and design work of other disciplines; checked for proper cross-referencing to computer output; assessed the adequacy of design verification; reviewed the design drawings; and determined if specifications and drawings were up to date.

The draft work package reports were reviewed by HL&P and Brown & Root, with comments being resolved by Bechtel, often in three-party meetings. After incorporating comments into the final report for each work package, Bechtel submitted the report to HL&P with a set of reproducible work package documents for retention as a project record.

Bechtel's assumption of the construction management responsibility necessitated that South Texas be physically examined to determine the status of construction at the project. Among the key aspects of Bechtel's review was a series of "walkdowns" which collectively covered completed construction. During these walkdowns, Bechtel and Brown & Root personnel visually checked the installed sections of the plant against applicable design drawings. The drawings were marked up to reflect the extent to which construction of the items represented on the drawings had been completed. The walkdowns also assured that construction had proceeded according to the design or alternatively recorded the extent of any deviation from the design. Following each walkdown, Bechtel audited the QC records for completed construction to verify that the records had been properly generated and maintained. Thus, Bechtel's review not only provided for a physical check of completed work, but also assured that proper documentation existed as evidence of proper QC inspection of the work.

Houston Lighting & Power Quality Assurance performed direct oversight of these evolutions with personnel stationed in Bechtel's design office and at the South Texas site. These oversight

methods included audits, surveillances, and package reviews. Identified deficiencies were documented in accordance with the corrective action program and resolved by Bechtel.

2.2 Engineering Assurance Program

In September 1983, Houston Lighting & Power developed an Engineering Assurance Program (EAP) at South Texas that was an ongoing independent review of the design to confirm the adequacy of the engineering work. The program specifically assessed the adequacy of the technical aspects, as well as the methods of control of engineering and design activities of HL&P and its major contractors, by independently sampling the design activities and products for confirmation by analytical techniques. Stone & Webster Engineering Corporation provided experienced personnel to supplement the Houston Lighting & Power Engineering Assurance staff. The assessment included design process reviews, independent technical assessments, and third-party design assessments. The EAP was separate from and in addition to the measures performed by Bechtel, Houston Lighting & Power, and others to satisfy design control and design verification requirements specified in the QA program.

Using the "vertical slice" methodology, the EAP also reviewed design control and design verification measures used to produce the design. This involved detailed technical examination of the design process for a selected portion of the plant, starting with design input and tracing through the development of design to the output of each of the major disciplines.

The initial list of subjects to be reviewed included:

Soil-structure interaction analysis
ASME III pipe stress analysis
ASME III pipe support design
Pipe break restraint and jet impingement shield design and analysis
Equipment environmental qualification
Rapid fuel handling
Fuel handling elevators and transporters
Single failure criteria: train separation and Appendix R implications
Containment analysis (LOCAs and other high energy breaks)
Offsite power supply
Medium-voltage AC system
Design control and design verification
Industry experience feedback

In August 1984, the NRC accepted the EAP as a substitute for an Independent Design Verification Program.

2.3 Construction Project Evaluation Program

During the summer of 1983, an evaluation of STP was conducted as part of the nuclear industry's construction project evaluation program developed and managed by INPO. The program

addressed performance objectives in the following areas: organization and administration; design control; construction control; project support; training; quality; and test control. The evaluators found that in general, the project design and construction control processes were effective in assuring that the design and construction quality goals were achieved.

During March - April 1985, INPO conducted a second evaluation under the construction project evaluation program. The evaluators found that the systems in place to control the quality of design and construction were being implemented effectively.

2.4 Pre-Construction Appraisal Team Assessment

After reviewing the results of NRC Construction Appraisal Team (CAT) inspections at nine other facilities, Houston Lighting & Power decided it would be beneficial to gain comparable insights with respect to STP. Therefore, in May 1985, Houston Lighting & Power initiated a "pre-CAT" assessment of construction activities and associated design and procedural aspects. The actual in-plant effort took approximately seven weeks and was conducted by a team of ten experienced contract personnel under the direction of Houston Lighting & Power Quality Assurance.

2.5 Certification of Technical Specifications

In the fall of 1985, South Texas formed a three-party review group with individuals representing Houston Lighting & Power, Bechtel and Westinghouse, to develop Technical Specifications for South Texas Unit 1. Each section of the Westinghouse Standard Technical Specifications (STS), NUREG-0452, Draft Revision 5 was marked up to reflect the South Texas three-safety-train design; to reflect plant specific design features such as rapid refueling, four auxiliary feedwater pumps, in-containment storage pool, and qualified display processing system; and to provide flexibility in areas where there exists 100 percent redundancy between the three trains.

In November 1986, Enercon Energy Services was contracted by Houston Lighting & Power to perform an independent review of the South Texas Technical Specifications as of July 1986. Enercon's objective was to assure that the specifications were consistent with the plant licensing basis and represented the current documented plant design. The specifications were reviewed against the FSAR, SER, system descriptions, design calculations and analysis, appropriate correspondence, the Final Environmental Statement, Environmental Report, and the Offsite Dose Calculation Manual. Enercon characterized the items identified as isolated errors and further stated that no evidence of programmatic deficiencies in the formalization of the South Texas Technical Specifications was found during the review process. Each problem or inconsistency identified during the review was recorded on a computerized Technical Specification review punchlist and resolved.

Bechtel and Houston Lighting & Power reviewed the Technical Specifications against the FSAR and provided additional changes to the FSAR to reflect then-current analysis and design calculations. Westinghouse certified to Houston Lighting & Power that the Technical Specification values within the Westinghouse scope were derived from the analyses and

evaluations included in the South Texas Project FSAR submitted pursuant to 10CFR50.34 and in accordance with the Westinghouse Quality Assurance Plan (WCAP-8370/7800).

In December 1988, South Texas completed certification of the final draft combined Technical Specifications for Units 1 and 2. A list of differences between the units was reviewed against the combined Technical Specifications to verify that the differences were accurately reflected in the combined Technical Specifications. Also the differences were reviewed to determine that they accurately reflected the as-built condition of both units.

2.6 Limited Readiness Review Audit Program

A Limited Readiness Review Audit program was developed by South Texas and conducted during 1985 - 1986 by a team of independent contractors under the direction of Houston Lighting & Power Quality Assurance. The selection of topics to be included in this program was based upon review of topics which had proven troublesome at other projects, may have been troublesome at South Texas, or which were of specific interest to South Texas. The topics selected were:

- Seismic interaction
- Concrete
- Material control
- Environmental qualification
- Structural steel
- Settlement monitoring

Each audit was a broad-scope technical audit conducted by a team of approximately five individuals including technical specialists. The audit included a review of the pertinent FSAR commitments and the translation of those commitments into work-directing documents. The teams also reviewed work-in-progress and inspected completed work.

The Limited Readiness Review audit and subsequent surveillances identified electrical equipment cabinet weld discrepancies, resulting in a program to reinspect 100% of the QC-accepted electrical equipment cabinet mounting welds on site. This program resulted in the identification of several deficiencies. Each of the deficiencies was corrected and corrective action was taken to prevent recurrence.

Also the Limited Readiness Review Audit of 40 substantially completed rooms found only one example of inadequate clearance between piping supports/restraints and other hardware.

2.7 Plant Completion Verification Program

Approximately four months prior to receiving the operating license for each unit, South Texas implemented a Plant Completion Verification Program (PCVP) to provide a consistent basis for management level verification of readiness to operate and to provide the necessary input for the

Facility Completion Letter. The PCVP was essentially the same for both units. The Unit 1 manager of plant completion reported directly to the Group Vice President, Nuclear.

The PCVP was developed as an enhancement to the normal method of determining operational readiness through the use of master punchlists and commitment tracking systems. This program was structured to ensure that prerequisites for fuel loading and plant operation had been completed and verified. The PCVP focused management attention on the licensing and/or regulatory commitments, as well as the myriad of activities that had to be completed to ensure the ability to operate STP in a safe and reliable manner. South Texas continued to utilize these normal methods as the basis for ensuring that the detailed regulatory commitments were satisfied in addition to the PCVP.

Periodic assessments of the accuracy and implementation of the PCVP were performed under the cognizance of the Nuclear Safety Review Board.

The verification items list that was completed prior to startup included such things as procedures in place, design bases established and turned over, design documents available, as-built reconciliation program complete, engineering walkdowns complete, design quality records complete, systems accepted by Operations, Technical Specifications verified, prerequisite and preoperational test records reviewed, post-maintenance test program in place, and surveillance test program in place.

2.8 Confidence in the Quality of Design, Construction, and Testing

In May 1987 (Unit 1) and in December 1988 (Unit 2), South Texas reported readiness for fuel load. Attachment 5 to both of the letters included a brief description of the programs that had been completed that gave South Texas confidence in the design, construction, and testing of the units. In addition to the programs described above, through September 25, 1988, there had been a combined (Houston Lighting & Power, Bechtel, Ebasco) total of 784 audits; 15,166 QA surveillances; 68 procurement overview surveillances; and 6,380 effectiveness inspections covering 161,382 attributes. Additionally, there were independent Bechtel audits of the South Texas QA program in 1980 and 1981, and a four-utility joint audit of the program in 1982.

2.9 System Turnover and Testing

The turnover of system control from the construction organization to the startup organization completed the initial phase of construction of the plant. At this point, the design was frozen and any design changes performed thereafter were under the control of the configuration control package process. The startup organization controlled work performed on the system, and performed prerequisite and preoperational testing. The prerequisite testing was generic in nature, and generally on a component basis. The preoperational tests procedures were produced in accordance with a startup administrative instruction and the bases for their acceptance criteria were the FSAR Chapter 14 paragraphs applicable to the particular equipment or system. Typically, acceptance criteria were that the tested parameters were "in accordance with system design requirements" as reflected in the FSAR. There were some overall preoperational tests

which tested overall plant response that also used the FSAR as the basis for the evolutions performed and the acceptance criteria for the testing. For systems which had no specified testing in the FSAR, the startup organization produced acceptance tests as required by another startup administrative instruction. The acceptance criteria for these tests were based on the system descriptions provided by the architect engineer and typically confirmed that systems functioned "in accordance with the system design and vendor's technical manuals."

Bechtel Engineering reviewed the startup test procedures to verify that safety-related functions and important power generation functions were included in the preoperational tests. The review established that the test objectives and acceptance criteria were in accordance with the design requirements. Sources used to verify the test procedures included system design criteria, system descriptions, FSAR sections, specifications, flow diagrams, and the setpoint list.

Upon completion of testing and the resolution of identified problems, the startup organization produced a turnover package controlled by procedure. This package provided details on testing performed on the system; the designated boundaries of the system; and any remaining testing, modifications, or non-conformances still open on the system components. In addition, system engineers coordinated system walkdowns by operations, maintenance and startup personnel. These walkdowns were documented along with any issues discovered which were either resolved or added to the tracking list noted above. The walkdowns included a verification that the in-plant status was accurately reflected in the design drawings. Finally, the system engineer provided details of the maintenance performed on that system prior to turnover in order to establish the equipment history for the system.

2.10 Design Basis Documents

As part of the assumption of design responsibility from Bechtel, Houston Lighting & Power initiated a program to ensure the accessibility of design bases information and source documents. Houston Lighting & Power commissioned the creation of Design Basis Documents (DBDs) for selected systems and design topics. More than 40 DBDs were generated covering the most significant systems and topics. The DBDs provide a description of the design bases and a cross reference to the calculations, drawings, and analyses that form the design bases. These documents were prepared using existing design bases information by Bechtel and Westinghouse in a standard format which provided system and component design functions and parameters and reference to the source document from which the information was obtained. The preparation of these documents required identifying that source documents for the design functions and parameters existed and were available. The instructions given to the developers of the DBDs required them to gather design inputs in accordance with ANSI N45.2.11, Section 3.2. The completed DBDs were subjected to design verification using existing procedures based on ANSI N45.2.11. Finally, a Houston Lighting & Power reviewer performed a technical review of each DBD before it was approved. When NUMARC 90-12 was issued, the DBD program was in progress. The recommendations of NUMARC 90-12 were reviewed and confirmed as being addressed in the program plan. The DBDs continue to be maintained as living documents that are updated as design bases and configuration information is changed or developed.

The 1996 Engineering self-assessment identified some developing problems with the accuracy and use of DBDs. These problems included inconsistent understanding of the role of the DBDs and DBD maintenance problems associated with incorporation of amendments. Corrective actions have been established which include communicating management expectations with regard to DBD maintenance and use, and improvements in DBD maintenance. Specific inaccuracies are being identified and corrected.

2.11 Summary

South Texas underwent extensive self-initiated scrutiny during its construction phase to ensure that the plant was properly designed and constructed. The Bechtel Transition Program, the Engineering Assurance Program, the Pre-Construction Appraisal Team assessment, the Limited Readiness Review Audit Program, and the Plant Completion Verification Program are examples of the extensive self-assessment that South Texas undertook in addition to the audits and inspections required by the Quality Assurance Program and other activities in response to and in support of regulatory reviews. These activities provide substantial confidence that the design bases were incorporated into the systems, structures, and components at South Texas at the time of construction completion.

The Design Basis Document development was a self-initiated effort that represents another layer of assurance that the design bases were translated into the plant. It also represents a useful tool for ongoing configuration control of the design bases of South Texas systems, structures, and components.

3.0 Engineering Design and Configuration Control Processes

Refer to the response to NRC request (a), Section 2, above for a description of the engineering design and configuration control processes that maintain the relationship between the design bases and the physical plant.

3.1 Post-Modification Testing Program

3.1.1 Program Description

Part of the procedural requirements of the design control process is the determination of appropriate post-modification testing activities. This may consist of three testing phases:

> Prerequisite testing verifies that installation is complete and is acceptable on a component basis, and that the system is ready for design change functional testing.
>
> Design change functional tests ensure that the design intent of the modification has been satisfied. Additionally, these tests ensure that the design basis functions of the component or integrated system are accomplished under required modes and conditions.

Operability tests are performed to ensure the modified system is operable as defined in the Technical Specifications and Updated Final Safety Analysis Report. Operability tests normally consist of the applicable equipment or instrument surveillance tests.

3.1.2 Self-Assessments

A Safety System Outage Modification Assessment was conducted in 1990, as described more completely in Section 4.3 below. One result was that Engineering developed a procedure to govern the development of post-modification testing that included a test matrix and other guidance as a tool for system engineers to identify testing requirements.

In the new design change process implemented in late 1994, Design Engineering was responsible for identifying necessary testing objectives and acceptance criteria for design changes. The modification team concept, which includes the system engineer and input from Operations, and a better understanding of equipment functional requirements improved the post-modification testing process. These enhancements were the result of several assessments of the design change process.

4.0 Configuration Consistent with Design Bases

4.1 Safety System Functional Assessments

South Texas has conducted four, vertical slice, safety system functional assessments (SSFAs) since 1989 that had aspects pertinent to consistency with the design bases.

4.1.1 Essential Cooling Water System

The late-1989 ECW SSFA was described in the response to NRC request (b), Section 4.1.1, above. There were also specific parts of the assessment plan that were intended to determine the following:

> Have modifications since the licensing of the plant altered the design in a manner such that it may not function as expected?
>
> Are management control processes effective to insure that the system will function on demand?
>
> Have modifications to essential support systems altered the likelihood that the primary system will function as expected?

The team discovered incomplete identification of affected documents before a physical change was made and incomplete/inconsistent implementation of document changes after the physical change was made. South Texas strengthened the configuration control process by revising the procedures to require system engineers to obtain input from the affected departments on the impact of the design change.

Two strengths were also observed by the team:

The design of the system was sound, with considerable design margin, flexibility, and reliability.

A large number of mechanical and electrical calculations and analyses were available. They were easily retrieved, well-documented, and generally provided an auditable trail to the design bases. System hydraulic and flow balances were particular strengths.

4.1.2 Auxiliary Feedwater System

During August - October 1991, South Texas conducted an SSFA on the auxiliary feedwater (AFW) system in accordance with SSFI techniques developed by the NRC. The specific objectives of the SSFA included determinations as to whether:

The AFW system design supports the performance of its safety function, without reliance on non-safety-related equipment considering the most limiting single active failure of safety-related equipment.

The system is installed in accordance with the approved design and the design is adequately implemented through operations, maintenance, and surveillance testing procedures.

The design bases are appropriately documented and has been preserved where modifications were performed (or justified through safety evaluations where changed).

Interfacing systems such as the isolation valve cubicle HVAC, vital AC power, vital DC power, main feedwater, and miscellaneous sumps were included in the assessment. The original design bases criteria and requirements were reviewed to establish design commitments. Design and installation documents and drawings (e.g., calculations, analyses, specifications, vendor material, modification packages, etc.) were reviewed to verify commitments were achieved. Operations, maintenance, and testing procedures were also reviewed to confirm adequate implementation of the design.

The team concluded that the AFW system will perform its safety function; it is installed in accordance with the design; the design is adequately implemented in plant activities; design bases documentation is adequate to support plant activities; and no modification deficiencies were identified.

The team also noted several strengths:

The basic system design is highly flexible and contains ample margin to support its required function.

The AFW system design basis document is generally thorough, accurate, and complete.

4.1.3 Essential Chilled Water System

South Texas conducted an SSFA of the essential chilled water system design, procedures, work history, and corrective actions in early 1993 with the following pertinent objective:

> Confirm that the essential chilled water system can perform its intended design basis functions on demand.

Two weaknesses were noted regarding the basis for system operation during low-load conditions and examples of inconsistent documentation of design changes. The low-load operation evaluation resulted in a change in the design bases for operation that was implemented through plant modification. The documentation issues were corrected.

4.1.4 Safety Injection System

In June - October 1993, South Texas conducted an SSFA as described in the response to NRC request (b), Section 4.1.4. This included assessment of the following specific functional areas:

> Determine the adequacy of the design bases; whether the existing configuration complies with the design bases; and whether the plant documents in which the design bases are described are consistent.
>
> Determine if changes made to the system are consistent with the design bases and if the design change process controls all documentation supporting the design change and maintains configuration control.

Identified problems were processed for resolution in accordance with the corrective action process or other established resolution processes.

4.2 Independent Technical Assessments

In April 1989, an independent technical assessment was conducted to verify and document the adequacy of the electrical power system design and control over the design process, including compliance with criteria, licensing commitments, and regulatory guides and standards. The specific topics of review included the concerns of NRC Generic Letter 88-15. The design was reviewed for voltages at Class IE equipment terminals, standby diesel generator (SDG) loading, SDG load transient response, fault current interrupting capability, breaker coordination, and Class IE battery sizing. The technical design of the power system was found to be adequate.

A second assessment was conducted in July 1989 to verify the overall functionality and adequacy of the maintenance and testing process related to the electrical power system at South Texas. Surveillance procedures, maintenance procedures, calculations, and associated documents were

reviewed. The assessment also reviewed the process for scheduling preventive maintenance, training of maintenance personnel, and spare parts inventories.

The assessment determined that the overall maintenance and testing process for electrical equipment was technically adequate and improving with procedure improvements, deletion of unnecessary procedures, and improved training of individuals. Several items of concern were identified, none of which presented plant operability problems.

The combined scope and the techniques employed during these two self-assessments covered some of the same areas as the NRC EDSFI that was conducted two years later.

4.3 NRC Electrical Distribution System Functional Inspection (EDSFI)

The NRC conducted an EDSFI at South Texas during May - June 1991, and noted in the Executive Summary of Inspection Report 50-498/499/91-05 that the team considered the overall design of the EDS to be adequate and well controlled. The team found the design bases of the EDS and supporting mechanical systems to be acceptably documented. The team noted several instances where the documentation appeared to be fragmented and not updated to reflect subsequent information. The team was particularly impressed with the procedural controls and maintenance associated with the station batteries and considered this to be a strength.

Further, the team found the engineering and technical support being provided for the operation of the facility to be superior. The team determined that prompt corrective actions had been implemented for identified problems and that critical self-assessments of various aspects of the facility design had been performed.

The team noted two programmatic weaknesses involving control of fuses and testing inverter devices. South Texas developed a fuse control program and inverter test procedures, and entered PM tasks for testing the inverter setpoints. The NRC closed these issues in early 1993.

The team noted one instance of a component not being restored to its design configuration, but South Texas promptly resolved this apparently isolated occurrence.

4.4 Safety System Outage Modification Assessments

During the second refueling outage of Unit 1 (February - June 1990), South Texas conducted an assessment of the plant modification process including design, implementation, and close-out. The assessment included technical reviews, field observations, and discussions with engineering, construction, and management personnel. It used methods and techniques similar to those used by the NRC in conducting their Safety System Outage Modification Inspections (SSOMI).

The assessment provided a real-time, independent evaluation of the effectiveness of the plant modification process. The team based its judgment of effectiveness on ensuring that design changes did not compromise the licensing and design bases of the plant. The team selected twelve plant changes and five temporary modifications for review based on the following:

- Complexity of the change
- Affected system's importance to plant safety or reliability
- Reason for the change
- Responsible engineering discipline
- Quantity of previous changes to the affected system, and
- Availability of approved design packages

The team concluded that the procedures governing the plant modification process provide assurance that the designer preserves the licensing and design bases of the plant and that design changes are documented, verified, and approved in a controlled manner from design through close-out. They found that management had successfully placed strong emphasis on ensuring that plant changes include careful analysis for conformance with the Technical Specifications and evaluation of unreviewed safety questions. This emphasis included in-depth training on the provisions of 10CFR50.59 and stringent oversight.

Weaknesses were noted in the implementation of some elements of the plant modification process. Identified problems were tracked for resolution in accordance with the corrective action program or other established resolution processes.

The team also identified several strengths including control and implementation of temporary changes; procedure improvements; Design Basis Documents; and accurate, clearly written 10CFR50.59 evaluations.

During the period of July - October 1995, the combination of a design engineering QA audit and a Nuclear Safety Evaluation covered the aspects of the modification process that would be addressed during an NRC SSOMI. The combined audit and evaluation process monitored the following activities:

- Organization, training, and qualification of personnel
- Development, review, approval, and control of permanent and temporary modifications
- Preparation of work packages
- Installation and testing of modifications
- Specifying equipment qualification requirements
- Configuration management
- Computer and database control
- Corrective action processes
- Management oversight and self-assessment
- Engineering evaluation of preventive maintenance

The audit concluded that the current modification process promotes effective maintenance of the design bases, thorough reviews of modifications, and continuous engineering involvement in the modification process.

Strengths identified by the audit team included the team approach to design changes, the two- and five-year modification plan, using an "implementation engineer" during the outage, and on-line capability of the master parts list.

The evaluation determined that the plant modification process, from work packaging through close-out, was well planned and implemented during the fourth Unit 2 refueling outage. Documentation of the work performed was adequate and timely.

Strengths identified during the evaluation included the application of computer-aided drafting (CAD) technology, use of "lessons learned" from other outages, communications, and modification work packages.

4.5 Engineering Assurance Modification Assessment

During the period of August - October 1994, South Texas conducted an assessment of six specific modifications to determine their technical adequacy and to assess the effectiveness of the modification program to control design change. The modifications selected for review primarily included instrumentation/electrical interface modifications in which design errors had previously been identified. The team reviewed the selected modifications for technical adequacy and independently analyzed associated design errors collectively to determine if any modification process or implementation weakness contributed to these errors. The team then reviewed the new modification program being developed to identify improvements that would eliminate the identified weaknesses.

The team concluded that the design change portion of the modification program had process and implementation weaknesses that in combination were significant in that they resulted in unanticipated or unconsidered impacts on plant equipment functional requirements. In two cases, safety-related equipment functions were impacted. The weaknesses included identifying basic equipment functions, design verification process and practices, identifying post-modification test requirements, interdisciplinary reviews, and communication of management expectations. Resolution of these weaknesses was considered in the development of the new modification program which was implemented in late 1994.

4.6 Engineering Self-Assessments

Engineering has an ongoing program of self-assessment, focused on improving performance in supporting plant operation and maintaining the design bases. Over the past three years, in addition to other self-assessments, Engineering has performed three large-scale assessments patterned after NRC engineering team inspections. These assessments are described in general below, however, specific issues are discussed throughout this response as they apply to areas of discussion.

During November 1994, a self-assessment was conducted to evaluate performance of the design change process and other areas. The multi-disciplined team included personnel from the

Engineering departments, Quality, Licensing, Maintenance, and Operations. The assessment objectives were based on NRC Inspection Manual Chapters 37550 and 37001. The team noted weakness in documenting interdisciplinary reviews of safety evaluations, but none of the examples noted impacted the conclusions of the evaluations. The new design change process was considered a strength because of the innovative design team concept.

During November - December 1995, several teams conducted a self-assessment of the Nuclear Engineering Department. Two areas of specific interest in the design control processes were the modification process and the temporary modification process. The technical content of the temporary modifications was found to be good. The new proposed temporary modification procedure was found to be a significant improvement in reducing complexity. No significant weaknesses or deficiencies were identified.

Another engineering self-assessment was conducted in October 1996. The self-assessment evaluated engineering activities utilizing the guidance provided in NRC Inspection Procedure 37550. The team was comprised of fourteen senior level South Texas personnel from Engineering, Quality, Licensing, Operations, and Maintenance and two industry peers (a design engineering supervisor from Palo Verde, and an engineering programs supervisor from Diablo Canyon) with recent experience in performing similar assessments.

One of the strengths identified was that the temporary modification program is characterized by high quality products that are effectively implemented and managed. No safety significant weaknesses were found, however concerns were raised in the area of Design Basis Document maintenance and accuracy, and in specific design bases calculations. The specific calculation issues were evaluated to be minor and the calculations were corrected. A broader issue with the adequacy of the setpoint calculations for some instruments was raised. This concern is being addressed through the corrective action program and may warrant programmatic action to update the design bases for these setpoints.

4.7 Review of the Updated Final Safety Analysis Report

South Texas is in the process of performing a comprehensive review of the Updated Final Safety Analysis Report (UFSAR) to improve the accuracy of the UFSAR and to streamline the UFSAR where appropriate. The review began in January 1996 and is approximately 70% complete. It is expected that the review will be completed in 1997.

The reviewers were assigned specific UFSAR sections based on their expertise in the topics covered. They were directed to check the accuracy of the UFSAR against the following types of documents: the Design Basis Documents, piping and instrumentation diagrams, calculation results, procedural requirements, the Technical Specifications, commitments to the NRC, the NRC Safety Evaluation Reports, and other statements made in the UFSAR. If inaccurate information is found or if design bases information is found to be missing, the reviewer is expected to initiate a condition report under the corrective action process to resolve the discrepancy. The review is intended to also identify any operating conditions or configurations considered to be "normal" that were no longer normal, or any "abnormal" conditions that had

become commonly accepted. The UFSAR review includes a review of docketed correspondence to identify any that should be considered for incorporation in the UFSAR. The reviewers were instructed that temporary changes that had been in place for more than one operating cycle should be included in the UFSAR. Also, reviewers were instructed that temporary changes implemented on a regular or recurring basis, such as during every refueling outage, should be considered for inclusion in the UFSAR.

No condition has been identified which involves an operability concern and no reportable conditions have been identified

4.8 10CFR50.59 Program Effectiveness

Early in the operating history, South Texas became concerned with the experience and understanding of the staff in documenting safety evaluations. South Texas established a detailed training course and, until the general staff experience improved, further required all evaluations to be reviewed and approved by a core review group of experienced engineers familiar with safety and accident analyses. As a result, the quality of the evaluations produced has been maintained at a high level.

4.8.1 Self-Assessments

The November 1994 Engineering self-assessment described in Section 4.5 above, also evaluated the 10CFR50.59 process. A sample of 10CFR50.59 screening forms and unreviewed safety question evaluations were reviewed for completeness and accuracy. Also, the implementation of 10CFR50.59 requirements in the procedural guidance was reviewed. The governing procedure was noted as a strength with excellent examples for evaluation of the questions on the screening and unreviewed safety question evaluation forms.

In August 1996, South Texas conducted a performance-based evaluation of the process for performing modification reviews, procedure changes, and similar activities that are governed by 10CFR50.59. The team reviewed selected license compliance review forms and the 10CFR50.59 evaluations associated with receipt inspection deficiency reports, temporary modifications, design change packages, and unreviewed safety question evaluations completed during the twelve months preceding the evaluation. Approximately 120 documents were reviewed. The team also reviewed reports by organizations other than the Quality Department to gain insight into the health of the 10CFR50.59 process.

The team concluded that the 10CFR50.59 process is in compliance with the requirements of the regulations and is effective in maintaining the design bases, in determining if unreviewed safety questions exist, and in identifying the need for changes to licensing documents. The evaluation identified one deficiency regarding the use of 10CFR50.59 evaluations as justification for another evaluation subject. Previously completed evaluations were being applied to later, similar subjects, but the later subjects were not identical to those previously evaluated. The manner in which 10CFR50.59 reviews were conducted for temporary modifications was changed as a result.

The team also noted strengths in training and the increased use of an electronic document text search system, both of which have contributed to more thorough reviews.

The October 1996 Engineering Self-Assessment described in Section 4.5 above also concluded that the 10CFR50.59 safety evaluation program is sound.

As a result of a management initiative not directly related to these self-assessments, South Texas will enhance the procedures that implement 10CFR50.59 to improve the application of the review criteria and additional training has been provided on the depth of documentation needed for 10CFR50.59 evaluations. As a result of the increased emphasis on design bases issues in the industry and the results of self-assessments, South Texas engineering and licensing management held meetings with the engineering staff in 1996. The purpose of these meetings was to reinforce engineers' understanding of the importance of maintaining the integrity of the design bases, the accuracy of design basis documents, and performing thorough and conservative 10CFR50.59 safety evaluations.

4.8.2 Independent Oversight

South Texas has also conducted many independent oversight audits, surveillances, assessments, and evaluations over the past nine years that addressed technical and programmatic adequacy of the 10CFR50.59 program. These included reviews of modification evaluations, design change packages, design change notices, requests for engineering action, plant change forms, conditional release evaluations, procedure changes, and other documents subject to 10CFR50.59 consideration. Identified problems were tracked for resolution in accordance with the corrective action program or other established resolution processes. In general, results have indicated that 10CFR50.59 evaluations are adequately performed and documented, and that the process is sound.

4.9 System Readiness Reviews/System Certification

In 1993, South Texas developed a process for certifying that critical systems were ready to support operation of the units. This process was designed to provide added confidence that the systems were in compliance with requirements, would perform their design function, and would support continued operation for an operating cycle. A panel that included representatives from Operations, Systems Engineering, and Maintenance, selected critical systems for certification using probabilistic safety assessment and deterministic input. These systems were then reviewed to identify required actions to make them ready for operation. These included correcting material deficiencies, action items from the station problem reporting program, action items from industry experience, and other sources. Each system was walked down with representatives from Nuclear Generation and the system engineer to ensure material deficiencies were identified. Each system was presented to a system readiness review board and the plant manager, who considered whether actions were completed, appropriately scheduled, or acceptable for deferral until after startup. At appropriate points in the startup schedule, each system was formally turned over to

Operations as ready to support continued operation. This process provided a high degree of assurance that the configuration of these systems was correct and properly documented.

An independent assessment plan was developed as part of the overall return to power operations program during the 1993 -1994 extended shutdown. Beginning in October 1993, a combined assessment group reviewed backlog reductions, specific hardware issues, operator workarounds, and other topics every two weeks to reach a conclusion about the effectiveness of the system certification and readiness review programs. Status reports were also presented to the Plant Operations Review Committee and discussed during their meetings.

4.10 Conversion to Improved Technical Specifications

South Texas has begun the effort to convert the station Technical Specifications to the Westinghouse Standard Technical Specifications format (NUREG-1431). The development of the improved Technical Specifications involves a detailed multi-departmental review of the proposed specifications and their bases. References used in the engineering review include the UFSAR and design basis documents. Some design bases issues have been identified and resolved in the course of the improved Technical Specifications development. None of the issues identified resulted in inoperable or reportable conditions.

4.11 Independent Oversight of Design Control Process

Since 1988, South Texas has conducted many audits, surveillances, inspections, assessments, and evaluations of design control programs and activities. These oversight activities assessed various topics, including the development and control of permanent and temporary modifications; work packages; equipment qualification requirements; configuration management; modification installation and testing; corrective actions ; and engineering evaluation of preventive maintenance. Objectives included considerations such as:

Process results yield design documents and physical installations that adequately maintain the design bases.

Procedures and instructions are technically adequate and controlled.

Computer programs and databases are adequately controlled.

Contractor engineering activities are controlled and monitored.

Problems are adequately identified and corrected.

The 10CFR50.59 process is adequately implemented.

System configuration changes are adequately controlled.

Identified problems have been resolved in accordance with corrective action programs or other established resolution processes. In general, oversight results indicate that the design control process is effectively implemented. Programmatic corrective actions have included enhancement of ALARA considerations, strengthening of post-modification testing, and major renovation of the design change process in 1994.

Specific strengths were noted in that calculations, change documents, 10CFR50.59 and unreviewed safety question evaluations are technically thorough; the 10CFR50.59 reviews are complete and contain technical justification for negative responses; and the Design Basis Documents are an excellent reference for system design inputs and design documents. The June 1995 audit noted the new modifications procedures as a strength by implementing a team approach to the design change process that inherently enables improved design and implementation.

5.0 Performance Consistent with Design Bases

South Texas has a number of programs in place to assess the performance of structures, systems, and components for consistency with the design bases.

5.1 ASME Section XI Pump and Valve IST Program

An assessment of the ASME Section XI pump and valve inservice testing (IST) program was performed during September 1994, by a multi-organizational team including a utility peer reviewer and an industry consultant. Assessment performance review criteria were developed using NRC Inspection Manual Chapters 110-03 and 114-03, the ASME code, Generic Letter 89-04, and NUREG-1482.

The assessment team concluded that the IST program was functional and met regulatory requirements, but had not matured as expected based on the age of the facility and as compared with the industry. Factors that had affected program development included documentation deficiencies, staff turnover, and insufficient management oversight of the program. The identified technical problems were subsequently corrected through preparation of the Bases Document. Additionally, since 1994, there has been no significant staff turnover and the program has received substantial management oversight.

The assessment recommended the development of an IST bases document as a key initiative to strengthen the program. In October 1994, the Section XI Group began development of an Pump and Valve IST Program Bases Document. This project consisted of a design bases review of ASME Class 1, 2 and 3 pumps and valves, development of technical justifications for the inclusion or exclusion of each component in the IST Program, and appropriate testing for each of the components in the Program.

The IST Program Bases Document is contained in three volumes organized by plant systems, and provides a technical justification for the inclusion or exclusion of ASME Class 1, 2 and 3

components. It is a living document that is routinely updated to incorporate changes in plant design and configuration.

5.2 System Engineering Department Activities

System Engineers are responsible for maintaining a technical overview of assigned system design, and for monitoring system operation, maintenance, and performance. One method used by the System Engineer is system walkdowns. The walkdown is more than a physical tour of a location, component, or area; it is regarded as a vital part of a System Engineer's responsibility that is expected to result in aggressive identification of adverse system conditions, prompting initiation of corrective actions and development of action plans before the overall system health is seriously affected. The walkdown is a detailed focus that System Engineers periodically place on assigned systems which concentrates on visual inspections, performance reviews, problem resolution, operational authority/plant operator/ craft feedback, and self training. This is documented in the System Engineer's walkdown (status) report which consists of reviewing trends provided from the System Performance Monitoring program and other sources, reporting the status of problems that have been resolved during the month or problems which are still open and require management attention and a statement of the overall health of the system. System health reports are presented by the System Engineer on a regular basis, usually one per week, to senior plant management at the Daily Communications and Teamwork meeting.

5.3 Maintenance Rule Program

As part of the Maintenance Rule implementation, the design bases for each system were reviewed and a list of the functions of each system was developed. The system functions were determined by reviewing the design basis documents, system descriptions, specifications, design criteria, and the UFSAR. The list of functions for each system served as a source of information for deciding which structures, systems, and components must be scoped under the Maintenance Rule and is used in determining the effect of component functional failures in Maintenance Rule scoped systems. When a component functional failure occurs, an evaluation is performed to determine whether a Maintenance Rule function was lost or could have been lost. The conservative Maintenance Rule Functional Failure determination criteria used at South Texas highlights potential problems as precursors, even when a Maintenance Rule function is not actually lost, so that the problems can be resolved before they impact the design basis functions.

5.4 Performance Monitoring Programs

Performance and condition monitoring encompasses equipment, components and systems critical to plant performance and provides for early detection and corrective action to improve and maintain plant reliability and availability. The System Performance Monitoring Program provides for the identification of trend parameters necessary to effectively monitor the performance of selected critical plant equipment/ components, identification of data collection frequencies and techniques required to achieve the specified level of monitoring, and the reporting of significant or adverse trends captured during the monitoring process.

The Predictive Maintenance Program utilizes a diverse set of technologies to identify and diagnose degradation in system or component performance prior to the failure of the component. This maintenance strategy focuses on the use of non-intrusive methodologies to achieve this goal. Vibration monitoring, infrared thermography, lubrication analysis, acoustic valve leak detection, and motor monitoring programs are utilized to detect component degradation prior to failures; thus increasing the reliability and safety of the units. The purpose of routinely monitoring components for adverse trends and anomalies is to improve plant performance and ensure that components continue to perform their design basis functions. As new predictive maintenance technologies become available they are evaluated to determine whether they will further enhance component reliability at South Texas.

5.5 Motor-Operated Valve Program

A program was developed to ensure that motor-operated valves (MOVs) will perform their design basis function for the life of the plant. This program outlines the related engineering, testing, maintenance, and licensing activities necessary to maintain design basis requirements. The MOVs within the scope of this program are design-verified through analysis and testing. Operational limitations associated with some plant systems prevent in-situ testing of all MOVs. Consequently, the program includes as an alternative to performing in-situ testing at valve design-basis pressure or flow conditions, a two-stage approach for the validation of the MOV design, application, and control switch settings. This two-stage approach involves a comparison with appropriate design basis test results from other MOVs

5.6 Preventive Maintenance Program

As related to conformance with the design bases, equipment qualification requirements are maintained through implementation of the preventative maintenance program. The program includes replacement management of life-limiting components for qualified equipment, installed plant instrumentation calibration verification, and instorage maintenance. The plant instrumentation calibration verification program is designed to ensure that permanent plant instrumentation is accurate where instrumentation scaling sheets are used to determine the required instrument accuracy. Instorage maintenance is that portion of the preventive maintenance program that refers to replacement items stored at South Texas.

The preventive maintenance program includes continuous review of existing preventive maintenance activities to determine their effectiveness, and evaluation of the preventive maintenance process and software, to identify elements that could benefit from enhancement. This effort is accomplished through an integrated approach composed of a comprehensive review of preventive maintenance tasks to develop a complete preventive maintenance basis and continuous feedback through both hardware failure trending and the preventive maintenance feedback process. The preventive maintenance program focuses on the expanded use of predictive maintenance and operator logs to facilitate the use of condition-directed tasks based on observed equipment condition. The purpose of this effort is to optimize the preventive maintenance program by focusing maintenance on the structures, systems and components that are critical to the availability and reliability of the plant.

In addition, South Texas has implemented a Plant Reliability Living Program to continuously improve the existing preventive maintenance program. This program consists of the continuous trending of component failures at the plant, system, component type and model number levels to identify focus areas for improvement and the development of preventive maintenance strategies to address any identified unreliability in these areas.

6.0 Conclusion

Due to South Texas' unique position during the construction phase, extensive efforts were undertaken to confirm that the as-built configuration of the plant conformed to the established design bases. These efforts have been carried through to the operations phase including real-time engineering involvement in modification installation activities, focused system engineering dedication to system health, operations and maintenance personnel sensitivity to configuration management/control needs, management oversight and aggressive self-assessment, and independent oversight. In concert, these efforts provide a high level of confidence that plant configuration and performance is maintained in accordance with established design bases. Identified problems are resolved in accordance with the corrective action program or other established resolution process, as appropriate. South Texas is committed to continue its policy of continued self-improvement and to maintain controls designed to ensure that the existing level of confidence is maintained.

Response to Information Request (d)

(d) *Process for identification of problems and implementation of corrective actions, including actions to determine the extent of problems, action to prevent recurrence, and reporting to NRC*

1.0 Introduction

South Texas has had a program for corrective action since construction began. The current program, referred to as the condition reporting process, was implemented in October 1994 to replace the station problem report program and other ancillary programs that had existed in varying revisions since the units were licensed. In generic terms, these programs are referred to as corrective action programs. The condition reporting process is the single, integrated process for identification of conditions station-wide. This process provides for reporting, evaluation, tracking, and correction of deficiencies, such as a material condition deficiency, a procedure deficiency, a procedure feedback, a request for engineering evaluation, a procedure violation, industry experience, etc. Conditions identified in this process can be directed to a number of interfacing processes, including maintenance, plant procedure changes, shutdown risk assessment, design change implementation, vendor technical information, design change packages, changes to licensing basis documents, and justification for continued operation.

The attributes that South Texas considers to be measures of a good corrective action process are:

Low threshold of problem identification
Timely completion of investigations and corrective actions
Effectiveness of corrective actions in preventing recurrence
Ability to identify both hardware and programmatic trends
Consistent implementation of the condition reporting procedure
Maintaining a high quality database for tracking and trending

South Texas performance relative to these attributes is closely monitored by the management team. Particular strengths in the program that enhance achievement of these attributes include:

Program ownership and implementation by line supervisors
Operability and reportability reviews
Active promotion and encouragement of problem reporting
Required effectiveness reviews of significant conditions
Direct management involvement and awareness
Condition Review Group oversight
Department quarterly assessments reviewed by management
Monthly independent and self-assessment with performance measures
Senior management oversight

The significant features of the process are described below.

2.0 Process Description

As defined in the condition reporting process, a condition is the existence, occurrence, or observation of a situation that requires further review, evaluation, and/or action for resolution. There are four levels of conditions defined in the process:

- Condition not adverse to quality (CNAQ)
- Condition adverse to quality-departmental level (CAQ-D)
- Condition adverse to quality-station level (CAQ-S)
- Significant condition adverse to quality (SCAQ)

The condition reporting process provides a method to identify and correct a condition at the lowest level of responsibility. This empowers personnel and creates an attitude of ownership and responsibility deep within the organization. Anyone on the station can initiate a condition report and it is the responsibility of everyone on the station to ensure that condition reports are written for conditions adverse to quality.

The individual responsible and accountable for the resolution of a condition is known as the condition owner. Condition owners are responsible for the resolution of conditions, including implementation, accuracy of information in the database, monitoring the effectiveness of corrective actions, and retention and vaulting of objective evidence of completed actions, as appropriate.

The condition reporting process procedure specifically addresses operability and reportability determinations and reporting to the NRC. Generic Letter 91-18 was used as the basis for the requirements for operability reviews and is referenced in the procedure. Condition reports with potential operability or reportability issues are taken to the shift supervisor for his review. The shift supervisor may obtain assistance from other organizations to make operability and reportability determinations, but the responsibility for these determinations remains with the shift supervisor. Certain dispositions of a condition report will result in the generation of a 10CFR50.59 evaluation.

There are two generally distinct paths for condition reports depending on whether the condition is a material condition deficiency or a programmatic issue. Material condition deficiencies are routed to the walkdown group in work control for further evaluation, planning, scheduling, and completion in accordance with the twelve-week scheduling process. Programmatic issues are investigated by the owner or assigned to a designated investigator. The level of effort put into the investigation is determined by the significance of the condition. In some cases an Event Review Team may be used to perform the investigation.

The condition reporting process requires that investigators of SCAQs be trained in root cause analysis through completion of a station certification in investigation or equivalent. SCAQs are required to have a root cause analysis which includes identification of generic implications and corrective actions to prevent recurrence, including those that address generic implications.

Following completion of corrective actions on a SCAQ, the owner is responsible for performing an effectiveness review to determine if the desired results have been attained.

The Condition Review Group (CRG) is a designated group of key line managers (e.g., Operations, Maintenance, Engineering, Quality, Licensing, etc.), chaired by a plant manager, that currently meets twice a week to provide collective oversight and consistent implementation of the condition reporting process. The CRG activities typically include:

- Validating condition significance determinations
- Reviewing investigations conducted by an Event Review Team
- Reviewing the results of selected SCAQs
- Reviewing condition owner assessments of corrective actions
- Reviewing significant corrective actions greater than 120 days old
- Reviewing SCAQ effectiveness reviews
- Approving extension of due dates for significant condition actions
- Approving downgrading the significance level of condition reports
- Monitoring the number of condition reports written
- Approving the investigations of adverse trends

The CRG also closely follows the condition reporting process to ensure that the threshold for identification of conditions is appropriately low and has taken specific steps to recognize employees for identifying less obvious conditions. Since implementation of the condition reporting process, South Texas has experienced a significant increase in the number of minor conditions reported. This strongly indicates that the condition reporting process is widely accepted and used by plant personnel, and that the threshold for problem identification and reporting has been successfully lowered.

An additional high-level performance measure has been established to assesses identification, timeliness, effectiveness of corrective actions, trending, implementation, utilization, quality, and process health. This performance measure is evaluated monthly based on quantitative and qualitative input, is reviewed by senior management, and is published in the station monthly report. Additional review of selected SCAQs is accomplished by the Plant Operations Review Committee and senior management oversight is also provided by the Nuclear Safety Review Board.

Line managers are responsible for program implementation in their respective area of responsibility and are held accountable for implementation of the process by their peers on the CRG. Each line manager is expected to be personally involved in the condition reporting process, actively promoting and encouraging the identification and reporting of problems. Line management is also responsible for performing quarterly assessments of process implementation in their respective department and for presenting the results of their assessment to the CRG. These assessments include evaluation of any trends identified during the quarter.

The condition reporting process requires that conditions adverse to quality be trended for repeat occurrences of an issue, both programmatic and hardware. Thresholds are established that will trigger generation of a condition report when a threshold is exceeded. In the case where a trend continues, the program requires the evaluation of the trend to determine if it is an adverse trend. Adverse trends require generation of a SCAQ which, in turn, requires a root cause analysis to be performed.

Based on the wide acceptance and use of the condition reporting process by station personnel, and on independent oversight of the process, we believe that the process is, and will continue to be, effective in identifying, tracking, and correcting deficiencies at South Texas.

Response to Information Request (e)

(e) *The overall effectiveness of your current processes and programs in concluding that the configuration of your plant(s) is consistent with the design bases*

As described in the responses to NRC requests (a), (b), (c), and (d), past and current processes and aggressive management oversight, self-assessment, and independent oversight activities provide reasonable assurance that the configuration of South Texas is consistent with the design bases. The following provides a summary of topics covered in the earlier parts of this response and summarizes the basis for this conclusion.

The South Texas units were licensed to operate at full power in 1988 and 1989, making South Texas one of the last plants to receive operating licenses. South Texas has had a unique history since the early days of construction. In the early 1980s, a decision was made to change the architect/engineering firm responsible for the design of the plant. This resulted in a comprehensive transition process and detailed re-evaluation and review of the design bases of the plant. Additionally, the change made South Texas sensitive to the oversight of the design process and capturing of design bases information. South Texas had a team of experienced engineers located in the architect/engineer's offices to oversee the design process and to ensure that utility personnel understood the design bases. Aggressive independent oversight was maintained throughout this phase and beyond. Also, South Texas instituted an Engineering Assurance program to provide independent vertical slice evaluations of the architect/engineer's work and additional confidence in the design bases. To ensure that knowledge of the design bases was retained, South Texas developed a set of Design Basis Documents that describe the design bases of key systems and provide a reference to the location of design bases calculations, analysis and drawings.

The current Technical Specifications are based on the Standard Technical Specifications for Westinghouse plants, and a certification process was employed prior to receipt of the operating license. Also in the process of obtaining the operating license, a plant completion verification program was completed as a basis of certifying that the plant was built in accordance with the design. Both of these activities are described in docketed correspondence.

The Final Safety Analysis Report (developed in accordance with Regulatory Guide 1.70 and the Standard Review Plan) was updated and resubmitted in 1989, and designated the Updated Final Safety Analysis Report. Updates to the UFSAR were submitted in 1990, 1991, 1992, 1994, and 1996. In early 1996, a review of the UFSAR for accuracy was initiated using in-house personnel. This review is currently about 70 percent complete. Issues identified as part of this review are being handled in accordance with the corrective action program. The issues identified are reviewed as appropriate for operability and reportability; to date, none of the issues has resulted in equipment being declared inoperable or the identification of reportable issues. Additional review of the design bases has also been performed in the process of converting the South Texas Technical Specifications to the improved Technical Specification format.

Since the initial operating licenses were issued, design bases issues have been identified during various audits, assessments, and inspections; some of these have resulted in Licensee Event Reports and Notices of Violations. As these issues are identified, corrective actions are taken in accordance with the corrective action program or other established resolution processes. In several of these cases, significant programs were undertaken to resolve the issue (e.g., Surveillance Procedure Enhancement Program, Operating Procedure Upgrade Program, comprehensive plant re-labeling program, review of the fuse list, development of a setpoint design basis document, master equipment database upgrade, and master parts list upgrade). A qualitative review of South Texas Licensee Event Reports and Notices of Violation performed to support this response did not identify significant trends or unresolved concerns regarding design bases issues.

During 1993 and 1994, issues were identified that were not directly related to compliance with the design bases, but resulted in assessments, inspections and reviews, and improvement in material condition, enhanced the corrective action process, and provided confidence in compliance with the design bases. Close management oversight and assessment of ongoing station activities, including the corrective action process, material condition, and compliance, have been essential to the continuing improvements at South Texas.

Since 1994, particular emphasis has been placed on the corrective action process. This is a formal process required for documentation of conditions adverse to quality, including non-conforming conditions. The current process receives a high level of department and senior management oversight and involvement, including frequent reviews to assess the effectiveness of the process. Assessments of the process show that it is successful in capturing issues that need to be resolved and providing for their resolution.

South Texas has an audit and inspection program designed to meet or exceed the requirements of 10CFR50 Appendix B. Additionally, substantial amounts of other forms of independent oversight (e.g., Engineering Assurance, SSFAs, SSOMIs, Nuclear Safety Evaluations, surveillances, performance monitoring, and reviews) have been accomplished over the years. These efforts are over and above regulatory requirements. Oversight activities have been performed on the processes which control conformance with the design bases, including those that implement configuration control, 10CFR50.59, design control, and 10CFR50.71(e). Issues identified from these efforts have been and continue to be resolved in accordance with the corrective action program. South Texas has assessed and audited past 10CFR50.59 evaluations and has found the evaluations typically of high quality. Enhancements to the program have been made as a result of these audits and assessments. There have been cases where missing design basis documentation was identified, and in those cases, the corrective action program was used to identify the issue and track the resolution. South Texas is committed to a program of aggressive independent oversight and to maintaining a high level of focus on effective maintenance of the design bases, including the performance of vertical slice assessments.

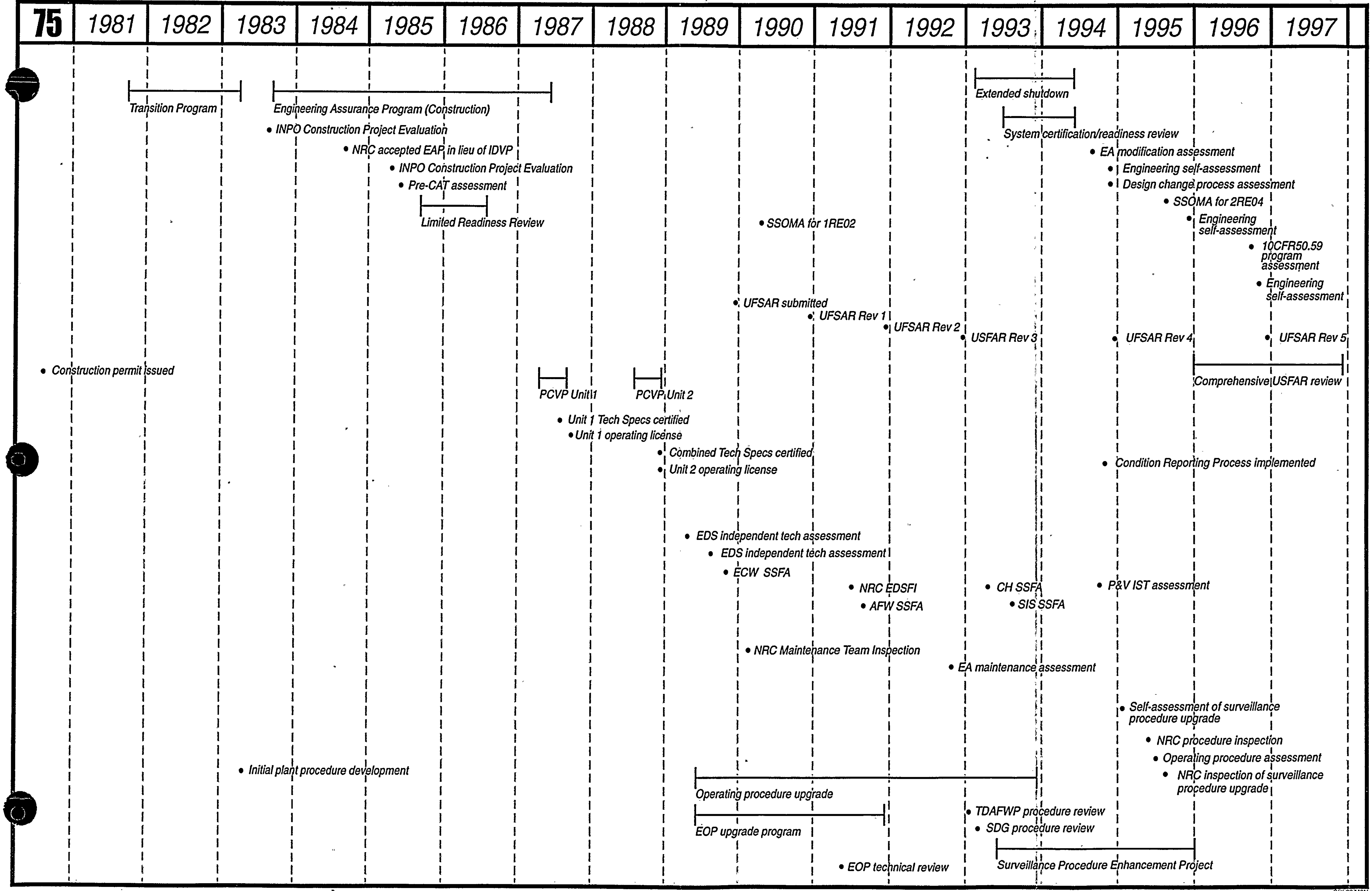
South Texas began an Engineering Assurance function during the project construction phase to perform independent, third-party, real-time reviews of the engineering work performed by Bechtel. These assessments were defined as a review of practices, processes and products to

determine if they were consistent with the design bases and operating parameters, and were achieving the desired results. Since the units went into operation, South Texas has continued this engineering assurance function for revisions and modifications to plant design after commercial operation began. This group is now referred to as Engineering Quality in the Quality Department. The department is organized to provide independent oversight along the site functional areas of engineering, operations, maintenance, plant support, procurement and nondestructive examination.

The above rationale provides a reasonable basis for concluding that the configuration of South Texas is being controlled in accordance with the design bases.

Chronological Perspective

The following timeline graphically depicts pertinent events described in this response and is provided to assist the reader in understanding the chronological relationship of the events.


1981
1982
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1987
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1991
1992
1993
1994
1995
1996
1997
Transition Program
Engineering Assurance Program (Construction)
INPO Construction Project Evaluation
NRC accepted EAP in lieu of IDVP
INPO Construction Project Evaluation
Pre-CAT assessment
Limited Readiness Review
Extended shutdown
System certification/readiness review
EA modification assessment
Engineering self-assessment
Design change process assessment
SSOMA for 2RE04
SSOMA for 1RE02
Engineering self-assessment
10CFR50.59 program assessment
Engineering self-assessment
UFSAR submitted
UFSAR Rev 1
UFSAR Rev 2
USFAR Rev 3
UFSAR Rev 4
UFSAR Rev 5
Construction permit issued
Comprehensive USFAR review
PCVP Unit 1
PCVP Unit 2
Unit 1 Tech Specs certified
Unit 1 operating license
Combined Tech Specs certified
Unit 2 operating license
Condition Reporting Process implemented
EDS independent tech assessment
EDS independent tech assessment
ECW SSFA
NRC EDSFI
AFW SSFA
CH SSFA
SIS SSFA
P&V IST assessment
NRC Maintenance Team Inspection
EA maintenance assessment
Self-assessment of surveillance procedure upgrade
NRC procedure inspection
Operating procedure assessment
NRC inspection of surveillance procedure upgrade
Initial plant procedure development
Operating procedure upgrade
EOP upgrade program
TDAFWP procedure review
SDG procedure review
Surveillance Procedure Enhancement Project
EOP technical review
CPI-00773N