BALTIMORE GAS AND ELECTRIC

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April 7, 1993

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Emergency Diesel Generator Project - Diesel Generator Qualification Report, Revision 1

REFERENCE: (a) Letter from Mr. R. E. Denton (BG&E) to NRC Document Control Desk, dated January 29, 1993, Emergency Diesel Generator Project - Diesel Generator Qualification Report

Gentlemen:

Following a meeting between Baltimore Gas and Electric Company and the NRC (March 17, 1993) concerning the review of the Diesel Generator Qualification Report (Reference a), several changes were made to the Qualification Report. These changes were made as a result of issues raised at the meeting. We have revised the Qualification Report and are providing you with Revision 1.

One of the issues discussed at the meeting concerned the sequence in which the testing is done. We do not imply a particular sequence to the tests by the order in which they are listed in the Qualification Report. We may choose to perform the tests in a different order than is given. Additionally, we will notify you before the Integrated Safeguards Pre-operational testing is performed, in the event that you wish to witness the test.

Two other items were raised at the meeting which we wish to clarify. One item concerned the sequencers we intend to use for this project. We will be using the existing sequencers for the new diesel generators. Another issue involved the monitoring equipment and the diesel alarms in the Main Control Room. Alarms will be provided in the Main Control Room equivalent to those already provided for the existing diesel generators. Monitoring and trending equipment (if any) will be non-safety-related and will be housed in the new Diesel Generator Building. This trending equipment will not provide any information to the Main Control Room.

Should you have any further questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

RED/PSF/psf/dlm

Attachments

cc: D. A. Brune, Esquire
J. E. Silberg, Esquire
R. A. Capra, NRC
D. G. McDonald, Jr., NRC
T. T. Martin, NRC
P. R. Wilson, NRC
R. I. McLean, DNR
J. H. Walter, PSC

ATTACHMENT (1)

SACM DIESEL GENERATOR QUALIFICATION REPORT

1.0 PURPOSE

The purpose of this report is to establish that the qualification requirements outlined in Regulatory Guide 1.9, Revision 3 (draft*) and IEEE-387 (1984) will be met for the SACM tandem diesel generators (GEN-SETs) by a combination of previous qualification testing, engineering analysis, and functional testing of the Calvert Cliffs GEN-SETs performed both at the vendor's facilities and in the field.

2.0 QUALIFICATION REQUIREMENTS

The qualification requirements for diesel generators used as emergency power sources for nuclear power stations are identified in Section 2 of Regulatory Guide 1.9, Revision 3 and Section 7 of IEEE-387 (1984). Qualification testing is intended to provide sufficient confidence that the emergency power sources (diesel generators) will meet the engineering design requirements under all expected environmental conditions.

As described in IEEE-387, initial design qualification is accomplished by the performance of type tests, or analysis, or a combination of both. This type testing has been completed on previously-supplied SACM GEN-SETs (see Section 3.A). We propose to qualify the Calvert Cliffs GEN-SETs by performance of factory production tests and in-situ pre-operational testing. The testing recommendations, extracted from IEEE-387, include a load capability test, start and load acceptance tests, and margin tests. Paragraph 7.2.2 of IEEE-387 (1984) also requires that, "A total of 300 valid start and loading tests shall be performed . . . ." However, due to the previous type testing performed on Class 1E SACM GEN-SETs, we are proposing a more limited testing program (see Section 3.C.2.a).

Regulatory Guide 1.9, Revision 3 (draft) provides guidance for supplementing requirements given in Section 7 of IEEE-387 (1984). Regulatory Position 2.3.1 describes pre-operational testing for diesel generators and requires, "a minimum of 25 valid start-and-load demands in accordance with Regulatory Positions 2.2.2 and 2.2.3 . . . ." Those regulatory positions require that a load-run test be performed and that we perform fast starts from standby conditions. We will perform the required 25 start tests, however, as described in Section 3.D.2, we will perform approximately one-half of those starts as slow starts from standby conditions. This reduces the wear on the GEN-SETs caused by fast starts (Generic Letter 84-15) and tests the slow start circuitry. Slow starts will comprise the majority of our Technical Specification surveillance tests.

3.0 QUALIFICATION TESTING

A. Qualification Type Testing

Qualification test results from five representative sites, using the SACM-designed Model UD45 diesels (the same as those purchased for Calvert Cliffs) are listed in this section.

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* The draft version of the Regulatory Guide that we base our program on is the version issued by the NRC in April 1992.

ATTACHMENT (1)

SACM DIESEL GENERATOR QUALIFICATION REPORT

Enclosure (1) identifies the major components and parameters of each of the five sites listed below and provides a comparison to our GEN-SETs.

1. Krummel

Start and load acceptance tests as defined in IEEE-387 (1972) were conducted for the Model UD45 diesel at the Krummel Nuclear Plant in Germany. The site was supplied with three V16 and three V20 versions of the Model UD45 diesels. The V20 version, due to its larger capacity, was selected by the utility for type testing to qualify both Model UD45 diesels. Site testing on one of the GEN-SETs included over 600 successful test cycles (start and load) without a failure. Enclosure (2) contains a discussion of the test methodology and results obtained during these test cycles.

It should be noted that the qualification testing successfully performed at the Krummel facility for the Model UD45 diesel exceeds the present IEEE-387 (1984) and NRC recommendations with respect to start and load reliability.

2. Electricite deFrance-Cruas

Start and load acceptance tests, according to IEEE-387 (1972) were performed on the diesel generators at the EdF-Cruas Nuclear Plant in France. The testing included over 1,500 successful starts without a failure on a Model UD45 engine. Based on these test results, a reliability of 1.0 was achieved. This exceeds the present French reliability standards of .99 based on the last 100 start attempts or .95 based on the last 20 start attempts. A summary (Enclosure 3) lists the test starts and subsequent loading.

Again, the number of successful starts on this Model UD45 diesel greatly exceeded present IEEE-387 (1984) and NRC requirements.

3. Asco

The tandem GEN-SETs for the Asco Nuclear Plant in Spain, powered by Model UD45 engines, were successfully start and load tested. Regulatory Guide 1.9, Revision 2, was used as a guideline for testing. Factory testing of these sets included over 100 starts with various subsequent loading profiles successfully applied. Enclosure (4) covers this factory testing as well as subsequent field testing.

4. Prairie Island

Start and load acceptance tests, as defined in Regulatory Guide 1.9, Revision 2 and IEEE-387 (1984), were conducted for the two tandem GEN-SETs (UD45) at the Prairie Island Nuclear Power Plant. Factory testing of these sets included 35 starts on each set with load acceptance reached within 10 seconds. A summary (Enclosure 5) lists the starts and subsequent loading.

5. Yonggwang

The four tandem GEN-SETs for the Yonggwang Nuclear Plant in Korea, powered by Model UD45 engines, were successfully start and load tested. IEEE-387 (1984) and Regulatory Guide 1.9, Revision 2, were used as a guideline for testing. Factory testing of these sets included over 300 starts with load acceptance reached within 10 seconds. Enclosure (6) covers this testing and subsequent loading.

B. **Analysis**

SACM has prepared an engineering evaluation of tandem versus single-driven GEN-SETs. The results of the evaluation are contained in Enclosure (7).

An additional engineering evaluation prepared by the EdF based on the SACM Model UD45 diesel indicates a very high confidence level for these types of SACM engines. Another document, "The Reliability of Emergency Generator Sets: Study - Experimentation - Operational Experiences," has been prepared by EdF and SACM for presentation at OPERA 89 (Operability of Nuclear Systems in Normal and Adverse Environments, Lyons, France, September 1989). The paper reports on the characteristics of emergency diesels and presents reliability statistics on GEN-SETs in service with EdF at the time of document preparation.

The results of each of these evaluations establishes that the Model UD45 diesel is qualified, either tandem or single, for use as a reliable emergency power source in nuclear power plants.

Additionally, SACM has implemented design changes to improve reliability and reduce excessive wear in the Model UD45 diesel engine. Each design enhancement has been evaluated by SACM and found not to impact the qualification of the diesel generator. The specific contribution of these changes to the overall increased reliability is difficult to determine since no previous failures were attributed to the areas that were modified. The effectiveness of these improvements was verified by a rigorous 1500 start test program at the EdF-Cruas Nuclear Plant.

C. **Factory Production Testing**

Initial testing will consist of vendor-specified combined "break-in" test runs, diesel engine performance test run and generator testing on each GEN-SET to verify acceptable GEN-SET operation. Qualification testing will be performed on each GEN-SET to verify load capability, start and load acceptance, and margin. These factory tests will verify the capacity, capability and reliability of the GEN-SETs. A synopsis of the methodology for each of these areas is listed below:

SACM DIESEL GENERATOR QUALIFICATION REPORT

1. Load Capability Tests

Each GEN-SET will be tested to demonstrate its capability to carry the loads as follows:

a. Load equal to 90-100% of the continuous rating until the engine oil and water system temperatures reach equilibrium plus one hour.

b. Short-time kilowatt nameplate load (105-110%) operation for a continuous period of two hours.

c. Rated kilowatt nameplate load (90-100%) operation for a continuous period of 22 hours.

d. Loss of short-time load transient response, with verification that the increase in the speed of the diesel does not exceed 75% of the difference between nominal speed and the overspeed trip setpoint, or 15% above nominal, whichever is lower.

e. Light or no load operation for a period of time recommended by the manufacturer followed by a load ≥ 2700 kw for a minimum of 0.5 hours.

The above 24-hour test will be performed without interruption on each GEN-SET. Premature termination of this test will require a repeat of the test.

2. Start and Load Acceptance Tests

A series of tests will be conducted to establish the capability of the GEN-SET to start, accept loads within a specified period of time, to meet the plant design requirements.

a. Start testing of both GEN-SETs, followed by 2700 ± 5% kw being applied in a single step, will be demonstrated 30 times with the GEN-SET at "keep warm" temperatures. Five additional start and load cycles will be performed from normal engine operating temperatures. The ability of the GEN-SET to start, accelerate to rated speed in ≤ 10 seconds, and supply the 2700 ± 5% kw step-load for a period of time to reach engine equilibrium conditions, will be the acceptance criteria for this test.

   The number of factory production test start and load cycles, together with the subsequent field testing, will adequately establish the GEN-SET start reliability and load assumption capability. This method is also consistent with the present effort to reduce excessive wear by testing, recently addressed by the NRC (NUREG/CR-0660, 4440, 4557 and 4590), while still verifying the overall reliability of the GEN-SET.

b. Each GEN-SET will be subject to one simulated loading sequence, using Calvert Cliffs load values. The test load values that are specified will be made up of both resistive and motor loads. The values chosen allow for an increase in safeguard loads.

A combination of motor (inductive load) and resistive load, equal to the first sequenced load, will be applied with voltage, frequency and load values monitored until steady-state conditions are reached. At that time, the motor load will be removed and the remaining resistive load will be increased to a value equal to the steady-state value of the motor load.

The next sequenced step-load will then be simulated using a combination of motor and resistive loads applied to the generator already supplying power to the total steady-state loads from any previous step(s). Three motors of different horsepower rating (approximately 250, 750 and 1,000 HP) will be used to produce the required motor load value. The size of the motor load will be changed as required to closely match the values specified for each sequenced step-load. This simulation of the step-loading sequence will be continued until the rated 5,400 KW generator load value is achieved. A loss of 105-110% load will be initiated with voltage and frequency (speed) monitored during the transient.

Acceptance will be based on successfully starting, accelerating to rated speed, and supplying the first and succeeding simulated loads until rated load is achieved. Acceptance will also be based on a loss of load not causing the diesel generator to exceed 75% of the difference between nominal speed and the overspeed trip setpoint, or 15% above nominal, whichever is lower.

3. Margin Tests

The purpose of the margin test is to demonstrate the GEN-SET's capability to start and carry loads that are greater than the magnitude of the most severe step load. Two margin tests will be conducted to ensure that the unit can withstand a step load (10% > largest single step, 1000 hp minimum) applied to the GEN-SET. The acceptance criteria for this test is given in IEEE 387-184, paragraph 7.2.3.

D. **Site Testing**

We plan a series of onsite tests to verify in-situ performance of the GEN-SETs and associated support systems. The major areas of the test program are listed below together with a summary of the primary objectives for each phase. The test program will be conducted using Regulatory Guide 1.9, Revision 3 (draft), as a test guideline. The frequency of the required tests is shown on Table 1. All phases of testing will be controlled by test procedures written according to the guidelines contained within Regulatory Guide 1.68, Revision 2 (August 1978) to document methodology, results,

and compliance with existing guidelines. The various phases of the test program are as follows:

1. Component Prerequisite Testing

The objective of this initial testing phase will be to verify controls, setpoints, and initial operation of the various components are per design. Initial operation of the GEN-SET, under the supervision of the vendor, will also occur during this time to reverify the operation of the diesel engine and controls.

2. Diesel Generator Pre-operational Testing

This initial system test will concentrate on the following areas of the emergency power system: controls, interlocks, alarms and monitoring system for the GEN-SET and various support systems. Starting air system logic and capability will also be demonstrated, as well as "keep warm" temperature control for the water and lube oil systems. Additionally, the pre-operational tests shown on Table 1 that do not require an emergency load will be performed during this phase.

In compliance with Regulatory Guide 1.9, Revision 3 (draft), Section 2.3.1, 25 in-situ start demands, followed by manual loading of the GEN-SET to 90-100% of continuous rating (KVA and power factor) using both resistive and inductive load banks for a minimum period of one hour, will be performed on each GEN-SET. Start criteria, as defined in Regulatory Guide 1.9, will be used as acceptance criteria to determine that no start failures occur during this test. Of the 25 start demands, 12 will be fast starts and 13 will be slow starts. All of the slow starts will be from a preheated, normal standby condition as will 9 of the 12 fast starts. The remaining three fast starts will be from a hot engine condition. Included in this test series is a demonstration of the GEN-SET's hot engine restart capability (after a 24-hour test run).

3. Integrated Safeguards Pre-operational Testing

The objective of this final test series will be to demonstrate the emergency power source response to simulated loss-of-offsite power (LOOP), safety injection and the combination of LOOP and safety injection demands using the actual plant loads, as activated by the loss-of-coolant incident (LOCI) sequencer. This verification of LOCI sequencer loading is also intended to demonstrate that the LOCI sequencer operation and load group assignments have not been changed as a result of this diesel generator addition. Additionally, redundant unit testing will be performed to confirm that this modification did not affect any other diesel generator's capability to respond as required.

4. Plant Surveillance Tests

Once the GEN-SETs have completed pre-operational testing, surveillance tests will be performed as defined by Technical Specifications. These tests will be described in conjunction with a request to incorporate the new GEN-SETs into the Unit 1 and Unit 2 Technical Specifications. Review and approval by the NRC of the surveillance test program will be requested.

4.0 OTHER QUALIFICATION ISSUES

This section addresses other issues related to the qualification of the diesel generators. These issues are addressed in greater detail in a separate design report.

A. Seismic Qualification

Section 7.4 of IEEE 387-1984 addresses the seismic qualification of diesel generators. The GEN-SETs for Calvert Cliffs will meet these seismic qualification requirements. The GEN-SET equipment will be qualified by testing, analysis, or by a combination of testing and analysis which meets the criteria of IEEE 344-1975 and Regulatory Guide 1.100 (1988). The GEN-SET purchase specification delineates the Calvert Cliffs site-specific seismic spectral response criteria. This spectral response criteria has been previously submitted to the NRC in the Civil Engineering Design Report (December 18, 1992). The diesel engines and the generators have been previously qualified to criteria which will be confirmed to envelope the Calvert Cliffs-specific criteria. Some peripheral equipment such as the auxiliary desk and the control panel will be directly qualified to the Calvert Cliffs specific-criteria. Diesel generator protective devices are Class 1E devices and are seismically qualified.

B. Environmental Qualification and Aging Requirements

The GEN-SET systems being provided to Calvert Cliffs will be located in a mild environment as defined in the GEN-SET purchase specification. The system components are supplied to the requirements of the purchase specification. The mild environment is defined as an environment that would at no time be significantly more severe than the environment which occurs during normal plant operation, including anticipated operational occurrences.

The engine room design air temperature ranges from +50°F to +120°F. This is based on an outside ambient temperature range of 0°F to +95°F. The humidity design criteria for of the equipment is 10 to 100% relative humidity, non-condensing.

The plant surveillance test program will address the vendor recommendations applicable to the safety related equipment and located in a mild environment to ensure continued satisfactory performance.

Section 7.3 of IEEE 387-1984 describes the aging requirements imposed on diesel generators. The aging requirements of the components and assemblies will be classified and qualified for the GEN-SET prior to being placed in service.

Section 5.5.1.2 of IEEE 387-1984 provides the criteria for determining the acceptability of torsional vibration. SACM has performed calculations of the torsional vibration (described in Enclosure 7) and determined that no harmful vibration occurs within ±5% of the synchronous speed or ± 10% of the subsynchronous speed.

5.0 CONCLUSION

The qualification recommendations of Regulatory Guide 1.9, Revision 3 (draft) and IEEE-387 (1984) will be met. The only departure from the testing by IEEE-387 (1984), Paragraph 7.2.2, is the change in the number of starts, from a total of 300 to 35 per GEN-SET. Regulatory Guide 1.9, Revision 3 (draft) recommends 25 fast start tests, however, we will be performing approximately one-half of these tests as slow starts.

The justification for these changes and the qualification of GEN-SETs is based on the following:

A. Previous successful qualification testing has been performed as described in Section 3.0. Major engine cranking and start system components used in the qualification testing at Krummel, EdF-Cruas, Asco, Prairie Island and Yonggwang Nuclear Plants, are the same as those of our GEN-SETs. Where component supplier differences occur, testing at other SACM installations has established their reliability.

B. The similarity between tandem and single engine-driven GEN-SETs has been addressed, both by engineering analysis and field test results. Therefore, the combined 2,400 successful start and load cycles, demonstrated at the Krummel and EdF-Cruas sites, coupled with the Asco plant testing, have more than adequately established the consistency and start reliability of this Model UD45 design.

C. SACM engineering documentation, in the form of component analysis, calculations and evaluations reports, with field test data feedback, establishes a sound basis for tandem versus single engine-driven diesel generator reliability (Enclosure 7).

D. Factory production tests and site testing will be performed in accordance with the recommendations of IEEE-387 (1984) and Regulatory Guide 1.9, Revision 3 (draft). This includes 35 factory qualification test starts with 25 additional site test starts on each GEN-SET.

TABLE (1)

PRE-OPERATIONAL AND SURVEILLANCE TESTING

Tests Described in Regulatory Guide 1.9[1] Regulatory Position 2.2		Pre-operational Test Program	Monthly Surveillance Tests	6-Month Tests	Refueling Outage	10-Year Tests
2.2.1	Start Test		X			
2.2.2	Load-Run Test	X	X	X[2]		
2.2.3	Fast-Start Test	X		X[2]	X	
2.2.4	Loss-of-Offsite-Power (LOOP) Test	X			X	
2.2.5	Safety Injection Actuation Signal (SIAS) Test	X			X	
2.2.6	Combined SIAS and LOOP Tests	X				X
2.2.7	Single-Load Rejection Test	X				X
2.2.8	Full-Load Rejection Test	X				X
2.2.9	Endurance and Margin Test	X				X
2.2.10	Hot Restart Test	X				X
2.2.11	Synchronizing Test	X				X
2.2.12	Protective-Trip Bypass Test	X				X
2.2.13	Test Mode Change-Over Test	X				X
2.2.14	Redundant Unit Test	X				X

[1] Revision 3 (draft) issued in April 1992.
[2] This test may be substituted for a monthly test.

ENCLOSURE (1)

DIESEL GENERATOR SITE-SPECIFIC COMPARISON

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
1.0	GENERAL CHARACTERISTICS						
1.1	Unit Model	UD45 V20 S5- Single Gen- Set 1 Engine & 1 Generator	UD45 V20 S5- Single Gen- Set 1 Engine & 1 Generator	UD45 V16 S5- Tandem Gen- Set 2 Engines & 1 Generator	UD45 V16 S5- Tandem Gen- Set 2 Engines & 1 Generator	UD45 V20 S5D Tandem Gen- Set 2 Engines & 1 Generator	UD45 V16 S5- Tandem Gen- Set 2 Engines & 1 Generator
1.2	Service	Nuclear Emergency	Nuclear Emergency	Nuclear Emergency	Nuclear Emergency	Nuclear Emergency	Nuclear Emergency
1.3	Environment	Mild	Mild	Mild	Mild	Mild	Mild
1.4	Ambient Conditions	+32 °C maxi + 5 °C mini +42 °C indoor	+40 °C + 5 °C +50 °C	+38 °C +10 °C +49 °C	+38 °C +10 °C +49 °C	+38 °C - 17 °C +50 °C	+40 °C +10 °C +49 °C
1.5	Elevation	30 Feet	340 Feet	164 Feet	695 Feet	Sea Level	45 Feet
1.6	Humidity	----	----	----	20 to 90 %	90 to 100 %	10 to 100 %
1.7	Engine Model	UD45	UD45	UD45	UD45	UD45	UD45
1.8	Type of Engine	V20 S5D	V20 S5D	V16 S5D	V16 S5D	V20 S5D	V16 S5D
1.9	Coupling	1x Elastic VULKAN EZ 201S	1x Elastic VULKAN EZ 201S	2x Elastic VULKAN EZ 171S	2x Elastic STROMAG GEF 3500 R	2x Elastic STROMAG GEF 3500 R	2x Elastic STROMAG GEF 2900 R
	Coupling size is different between a V16 and V20. The quantity of power distribution and available coupling space dictate the coupling manufacturer. STROMAG provides a coupling equivalent to the VULKAN, but requires less space, longitudinally, when assembled. Two couplings are required on a Tandem GEN-SET.						
1.10	Generator	SIEMENS 1DK38-	Jeumont-	Jeumont-	Jeumont-	Jeumont-	Jeumont-

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
		384 BE02	Schneider SAT-83-100-4	Schneider SAT-94-99, 5-4	Schneider SAT-100-100-6	Schneider SAT-107,5-100-6	Schneider SAT-100-100-6
	Generators are essentially of the same quality construction. They only differ in rating, and manufacturer, due to plant load requirements, and the national preference of the utility.						
1.11	Global Rotating Inertia Compl. Set	550.7 Kgm2	646.3 Kgm2	1459 Kgm2	1243,2 Kgm2	1357,5 Kgm2	1191,9 Kgm2
	Values listed for the Standem GEN-SETS are the total of both engines and therefore should be reduced by a factor of two for proper comparison. On a single engine basis, the Tandem sets represent 730 kgm2 and 624 kgm2 for the ASCO and NSP GEN-SETS respectively. These values are consistent with the ratings of the engines.						
1.12	Nominal Electric Power	4600 KWe	4120 KWe	4500 KWe	5400 KWe	6500 KWe	5400 KWe
	Power requirements are a function of the needs of the utility and the plant designed loads.						
1.13	Exciter/Voltage Regulation	German Mfgr.	French Mfgr.	French Mfgr.	USA Mfgr.	French Mfgr.	French Mfgr.
	The excitation and voltage regulation systems are all basically the same and differ only in national supplier of the equipment. Supplier differences occur in this area primarily due to scope of the generator supplier. Voltage regulation equipment may vary due to particular customer preference.						
1.14	Volts Phase	6900 V.	6600 V.	6900 V.	4160 V.	4160 V.	4160 V.
1.15	Frequency	50 Hz	50Hz	50 Hz	60 Hz	60 Hz	60 Hz
1.16	Rated Speed RPM	1500	1500	1500	1200	1200	1200
1.17	Rated BHP - Hr. (Metric) Per Engine Output	1x 6580 (V20) 1x 5000 (V16)	1x 5600 (V20)	2x 3150 (V16)	2x 3780 (V16) (Measured)	2x 3360 (V20)	2x 3796 (V16) (Calculated)

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
	Per Cylinder	329 (V20) 312 (V16)	280	197	237	168	239
1.18	Intentionally Left Blank						
2.0	ENGINE CHARACTERISTICS						
2.1	Code	French	French	French	French	French	French
2.2	Standard	Manufacturers	Manufacturers	Manufacturers	Manufacturers	Manufacturers	Manufacturers
2.3	Bore DIA	240 mm 9.45 in.	240 mm 9.45 in.	240 mm 9.45 in.	240 mm 9.45 in.	240 mm 9.45 in.	240 mm 9.45 in.
2.4	Stroke	220 mm 8.66 in.	220 mm 8.66 in.	220 mm 8.66 in.	220 mm 8.66 in.	220 mm 8.66 in.	220 mm 8.66 in.
2.5	Number of Cylinders	(1x) 20	(1x) 20	(2x) 16	(2x) 16	(2x) 20	(2x) 16
2.6	Cylinder Arrangement Angle	V 50°	V 50°	V 50°	V 50°	V 50°	V 50°
2.7	Number of Main Bearings	(1x) 12	(1x) 12	(2x) 9	(2x) 9	(2x) 12	(2x) 9
2.8	Total Displacement	204.4 l 12472 in3	204.4 l 12472 in3	163.5 x 2 l 2 x 9977 in3	163.5 x 2 l 2 x 9977 in3	204.4 x 2 l 2 x 12472 in3	163.5 x 2 l 2 x 9977 in3
2.9	Piston Speed	11 m.sec 35.5 ft/sec	11 m/sec 35.5 ft/sec	11 m/sec 35.5 ft/sec	8.8 m/sec 28.9 ft/sec	8.8 m/sec 28.9 ft/sec	8.8 m/sec 28.9 ft/sec
2.10	Crank Bearing DIA	180 mm	180 mm	180 mm	180 mm	180 mm	180 mm

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
		7.08 in.	7.08 in.	7.08 in.	7.08 in.	7.08 in.	7.08 in.
2.11	Crank Pin DIA	165 mm 6.49 in.	165 mm 6.49 in.	165 mm 6.49 in.	165 mm 6.49 in.	165 mm 6.49 in.	165 mm 6.49 in.
2.12	Piston Pin DIA	92 mm 3.62 in.	92 mm 3.62 in.	92 mm 3.62 in.	92 mm 3.62 in.	92 mm 3.62 in.	92 mm 3.62 in.
2.13	Piston to Head Clearance	2.1 mm/2.5 mm 0.083 in/ 0.098 in	2.1 mm/2.5 mm 0.083 in/ 0.098 in	2.1 mm/2.5 mm 0.083 in/ 0.098 in	2.1 mm/2.5 mm 0.083 in/ 0.098 in	2.1 mm/2.5 mm 0.083 in/ 0.098 in	2.1 mm/2.5 mm 0.083 in/ 0.098 in
2.14	Compression Ratio	12	12	12	12	12	12
2.15	Rated BMEP	18.0 bar 261 psi	16.2 bar 235 psi	13.64 bar 198 psi	17.06 bar 247 psi	17.06 bar 247 psi	17.23 bar 250 psi
2.16	Crankcase - References - Specification - Material	 62784 DLTD 14-1-1 AFNOR Ft 30C Cast Iron	 62784 DLTD 14-1-1 AFNOR Ft 30C Cast Iron	 627[illegible] DLTD 14-1-1 AFNOR Ft 30C Cast Iron	 140375 DLTD 14-1-1 AFNOR Ft 30C Cast Iron	 140380 DLTD 14-1-1 AFNOR Ft 30C Cast Iron	 140375 DLTD 14-1-1 AFNOR Ft 30C Cast Iron
2.17	Cylinder - References - Specification - Material	 62111 DLTD 14-4-2 Wizemann Std 45/ or Demolin 260 Centrifugal Cast Iron	 62111 DLTD 14-4-2 Wizemann Std 45/ or Demolin 260 Centrifugal Cast Iron	 62111 DLTD 14-4-2 Wizemann Std 45 or Demolin 260 Centrifugal Cast Iron	 140294 DLTD 14-4-2 Sadefa Centrifugal Cast Iron	 140294 DLTD 14-4-2 Sadefa Centrifugal Cast Iron	 140294 DLTD 14-4-2 Sadefa Centrifugal Cast Iron
2.18	Crankshaft - References - Specification	 122117 DLTD 14-5-1	 122117 DLTD 14-5-1	 62607 DLTD 14-5-1	 122054 DLTD 14-5-1	 122117 DLTD 14-5-1	 122054 DLTD 14-5-1

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
	- Material	42CD4 or 34 NCD6 or 40CD5 pr EN24	42CD4 or 34 NCD6 or 40CD5 or EN24	42CD4 or 34 NCD6 or 40CD5 or EN24	42CD4 or 34 NC6 or 40CD5 or EN24	42CD4 or 34 NC6 or 40CD5 or EN24	42CD4 or 34 NC6 or 40CD5 or EN24
2.19	Bearing Shell						
	- References	120961/120962	120961/120962	120961/120962	120961/120962	120961/120962	120961/120962
	- Specification	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2
	- Material	Steel With Copper Lead Layer	Steel With Copper Lead Layer	Steel With Copper Lead Layer	Steel With Copper Lead Layer	Steel With Copper Lead Layer	Steel With Copper Lead Layer
2.20	Camshaft						
	- References	120646/120647	120646/120647	120666/120662	124161/124162	120646/120647	124161/124162
	- Specification	DLTD 14-11-1	DLTD 14-11-1	DLTD 14-11-1	DLTD 14-11-1	DLTD 14-11-1	DLTD 14-11-1
	- Material	10NC6 or 12NC12 or 16NC6	10NC6 or 12NC12 or 16NC6	10NC6 or 12NC12 or 16NC6	10NC6 or 12NC12 or 16NC6	10NC6 or 12NC12 or 16NC6	10NC6 or 12NC12 or 16NC6
2.21	Oil Sump Frame						
	- References	122252	122252	72293	124698	122252	141234
	- Specification	DLTD 14-30-1	DLTD 14-30-1	DLTD 14-30-1	DLTD 14-30-1	DLTD 14-30-1	DLTD 14-30-1
	- Material	Welded Steel Plates	Welded Steel Plates	Welded Steel Plates	Welded Steel Plates	Welded Steel Plates	Welded Steel Plates
2.22	Timing Gear						
	- References	93831	93831	93606/93665	93831	DLF93831	NLF93831
2.23	Master Rod						
	- References	62544	62544	62544	62544	62544	62544
	- Specification	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1
	- Material	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
2.24	Articulated Rod						
	- References	62176	62176	62176	62176	62176	62176
	- Specification	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1	DLTD 14-8-1
	- Material	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6	AFNOR 35NCD6F or DIN 34 Cr Ni MO6
2.25	Master Rod Bearing Shell						
	- References	123351	123351	123351	123351	123351	123351
	- Specification	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2	DLTD 14-3-2
	- Material	Steel with Copper Lead Layer	Steel with Copper Lead Layer	Steel with Copper Lead Layer	Steel with Copper Lead Layer	Steel with Copper Lead Layer	Steel with Copper Lead Layer
2.26	Pistons						
	- References	123395	123395/124707	62110	140723	140723	141380
	- Specification	DLTD 14-6-4	DLTD 14-6-4	DLTD 14-6-4	DLTD 14-6-4	DLTD 14-6-4	DLTD 14-6-4
	- Material	AFNOR AS12UN	AFNOR AS12UN	AFNOR AS12UN	AFNOR AS12UN	AFNOR AS12UN	AFNCR AS12UN
2.27	Piston Rings						
	- References	123472 123473 120055 123474	123472 123473 120055 123474	121253 62116 120055 62114 120056 62115	140430 123473 120055 123474	140043 123473 120055 123474	141381 141382 120055 123475
	- Specification	DLTD 14-7-3	DLTD 14-7-3	DLTD 14-7-3	DLTD 14-7-3	DLTD 14-7-3	DLTD 14-7-3
2.28	Cylinder Head						
	- References	120686	120686	120686	120686	120686	120686
	- Specification	Indiv. 1 20	Indiv. 1 20	Indiv. 12x 16	Indiv. 12x 16	Indiv. 12x 20	Indiv. 12x 16
	- Material	DLTD 14-1-3	DLTD 14-1-3	DLTD 14-1-3	DLTD 14-1-3	DLTD 14-1-3	DLTD 14-1-3

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
		AFNOR Ft 30C Cast Iron	AFNOR Ft 30C Cast Iron	AFNOR Ft 30C Cast Iron	AFNOR Ft 30C Cast Iron	AFNOR Ft 30C Cast Iron	AFNOR Ft 30C Cast Iron
2.29	Valves						
	- Intake Ref.	123775	123775	120065	123775	123775	123775
	- Exhaust Ref.	123874	123874	121083	124980	124980	124980
	- Specification	DLTD 14-13-16	DLTD 14-13-16	DLTD 14-13-16	DLTD 14-13-16	DLTD 14-13-16	DLTD 14-13-16
	Intake - Material	Z45CS9	Z45CS9	30 NCD 16	Z45CS9	Z45CS9	Z45CS9
	Exhaust Material	Z25CNW21.10	Z25CNW21.10	Z25CNW21.10	Z52CMN21.9/ Z45CS9	Z52CMN21.9/ Z45CS9	Z52CMN21.9/ Z45CS9
2.30	Valve Seat						
	- Intake Ref.	123665	123665	61945	140874	140874	140874
	- Exhaust Ref.	123407	123407	121354	140874	140874	140874
	- Specification	DLTD 14-13-17	DLTD 14-13-17	DLTD 14-13-17	DLTD 14-13-17	DLTD 14-13-17	DLTD 14-13-17
	Intake - Material	Z200CD13.2	Z200CD13.2	30 NCD 16	Z200CD34.2	Z200CD34.2	Z200CD34.2
	Exhaust Material	Z200CD13.2	Z200CD13.2	Z200CD13.2	Z200CD34.2	Z200CD34.2	Z200CD34.2
2.31	Lower Liner Seal 1						
	- Reference	72448	72448	72448	72448	72448	72448
	- Material	Rubber D706 For Hot Water	Rubber D706 For Hot Water	Rubber D706 For Hot Water	Rubber D706 For Hot Water	Rubber D706 For Hot Water	Rubber D706 For Hot Water
	Lower Liner Seal 2						
	- Reference	72449	72449	72449	72449	72449	72449
	- Material	Viton DF801 For Hot Oil	Viton DF801 For Hot Oil	Viton DF801 For Hot Oil	Viton DF801 For Hot Oil	Viton DF801 For Hot Oil	Viton DF801 For Hot Oil
2.32	Cylinder Head						
	- References	71668/70362	71668/70362	71668/70362	71668/70362	71668/70362	71668/70362
	- Material	Copper	Copper	Copper	Copper	Copper	Copper
3.0	FUEL OIL SYSTEM						

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
3.1	Fuel Supply Pump Cap.	2500 L/h 11 GPM	2500 L/h 11 GPM	2500 L/h 11 GPM	2000 L/h 8.8 GPM	2000 L/h 8.8 GPM	2000 L/h 8.8 GPM
3.2	Fuel Supply Pump - Suction Lift - Max. Ft.	32 Ft.	32 Ft.	32 Ft.	32 Ft.	32 Ft.	32 Ft.
3.3	Nominal Fuel Consumption at Full Load	220 gr/kwh	220 gr/kwh	215 gr/kwh	210 gr/kwh	208 gr/kwh	210 gr/kwh
3.4	Firing Pressure	SACM Provides Values	SACM Provides Values	SACM Provides Values	SACM Provides Values	SACM Provides Values	SACM Provides Values
3.5	Injection Pump - References - Type/No. - Specification	36614 Indiv. / 20 DLTD 14-15-9	36614 Indiv. / 20 DLTD 14-15-9	36614 Indiv. 2 x 16 DLTD 14-15-9	36614 Indiv. 2 x 16 DLTD 14-15-9	DLF200454 Indiv. 2 x 20 DLTD 14-15-9	36614 Indiv. 2 x 16 DLTD 14-15-9
3.6	Injection Plunger	Outside	Outside	Outside	Outside	Outside	Outside
3.7	Fuel Injector - References - Type/No. - Specification	33736 Multi-holes DLTD 14-16-1	33736 Multi-holes DLTD 14-16-1	33736 Multi-holes DLTD 14-16-1	33736 Multi-holes DLTD 14-16-1	33736 Multi-holes DLTD 14-16-1	33736 Multi-holes DLTD 14-16-1
3.8	Fuel Pump - References - Specification	588332 DLTD 14-31-4	588332 DLTD 14-31-4	588332 DLTD 14-31-4	588332 DLTD 14-31-4	588332 DLTD 14-31-4	588332 DLTD 14-31-4
3.9	Fuel Backup Pump	No	Yes	Yes	Yes	Yes	Yes
4.0	LUBE-OIL SYSTEM						

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
4.1	Lube Oil Flow GPM	78m3 /Hr 343 GPM	78m3 /Hr 343 GPM	78m3 /Hr 343 GPM	68m3 /Hr 299 GPM	68m3 /Hr 299 GPM	68m3 /Hr 299 GPM
4.2	Lube Oil Pressure PSI	6.4 to 6.9 bar 92.8 to 100 PSI	6.4 to 6.9 bar 92.8 to 100 PSI	6.4 to 6.9 bar 92.8 to 100 PSI	6.4 to 6.9 bar 92.8 to 100 PSI	6.4 to 6.9 bar 92.8 to 100 PSI	6.4 to 6.9 bar 92.8 to 100 PSI
4.3	Oil Pump - References - Number	 200457 2	 200457 2	 200457 2 x 2	 200457 2 x 2	 200457 2 x 2	 NLT200457 2 x 2
4.4	Lube Oil Exchanger No.	2	2	2 x 2	2 x 2	2 x 2	2 x 2
4.5	Lube Oil Discharging Valve No.	2	2	2 x 2	2 x 2	2 x 2	2 x 2
4.6	Lube Oil Filter - No. - Type	 2 Single 3 Elements	 2 Single 3 Elements	 2 x 2 Single 2 Elements	 2 x 2 Double 2 Elements	 2 x 2 Double 2 Elements	 2 x 2 Double 2 Elements
4.7	Prelubrication (AC) Prelube Backup (DC)	Yes No	Yes No	Yes Yes	Yes Yes	Yes Yes	Yes No
4.8	Prelube Heater - Type	Yes Resistors	Yes Exchanger	Yes Resistors	Yes Exchanger	Yes Exchanger	Yes Exchanger
4.9	Turbocharger Lubrication - Type	Self-Lubricat.	Self-Lubricat.	Self-Lubricat.	Self-Lubricat.	Self-Lubricat.	Self-Lubricat.
5.0	WATER COOLING SYSTEM						

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
5.1	Type of Cooling Sys.						
	- HT Jacket Water	2 Circuits	2 Circuits	2 Circuits	2 Circuits	2 Circuits	2 Circuits
	- LT Comb. Air & Lube Oil	(HT & LT)	(HT & LT)	(HT & LT)	(HT & LT)	(HT & LT)	(HT & LT)
5.2	Type of Cooling						
	- Radiator	No	Yes	No	Yes	Yes	Yes
	- Heat Exchanger	Yes	No	Yes	No	No	No
5.3	Total HT H2O Flow GPM (Calculated)	200m3/Hr 880 GPM	200m3/Hr 880 GPM	180m3/Hr 792 GPM	155m3/Hr 675 GPM	150m3/Hr 660 GPM	145m3/Hr 640 GPM
5.4	Total LT H2O Flow GPM (Calculated)	180m3/Hr 792 GPM	180m3/Hr 792 GPM	140m3/Hr 616 GPM	130m3/Hr 570 GPM	200m3/Hr 880 GPM	120m3/Hr 520 GPM
5.5	Water Pump						
	- References	200936/200936	200936/200936	200936/200936	200936/200966	200936/200966	200937/200967
	- Specification	DLTD 14-31-6	DLTD 14-31-6	DLTD 14-31-6	DLTD 14-31-6	DLTD 14-31-6	DLTD 14-31-6
	- Material	Cast Iron	Cast Iron	Cast Iron	Cast Iron	Cast Iron	Cast Iron
5.6	After Cooler						
	- References	586526	586526	585846	612587	612587	612587
	- Specification	DLTD 14-18-3	DLTD 14-18-3	DLTD 14-18-3	DLTD 14-18-3	DLTD 14-18-3	DLTD 14-18-3
5.7	Thermostatic Valve						
	- HT	Yes	Yes	Yes	Yes	Yes	Yes
	- LT	No	No	No	Yes	Yes	Yes
	- Specification	---	---	---	DLTD 15-05-1289	DLTD 15-05-1330	1)Dltd 15-05-1568 2)Dltd 15-05-1569 1) HT- 2)LT
6.0	STARTING AIR SYSTEM						
6.1	Sterting System						

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
	Cylinder Injection - A Side - B Side	 Yes (10 cyl.) No	 Yes (10 cyl.) Yes (10 cyl.)	 Yes (2x8 cyl) Yes (2x8 cyl)	 Yes (2x8 cyl) Yes (2x8 cyl)	 Yes (2x10 cyl) Yes (2x10 cyl)	 Yes (2x8 cyl) Yes (2x8 cyl)
6.2	Starting Assembly	200863	200985/200983	200846/200848 200847/200845	200845/200846 200847/200848	200845/200846 200847/200848	200845/200846 200847/200848
6.3	Starting Air Filter	Yes	Yes	Yes	Yes	Yes	Yes
6.4	Starting Air Valve	Yes - SEITZ	Yes - SEITZ	Yes - SEITZ	Yes - SEITZ	Yes - SEITZ	Yes - SEITZ
6.5	Initial Starting Pres.	35 < P < 40 bar 508 to 580 psi	35 < P < 40 bar 508 to 580 psi	35 < P < 40 bar 508 to 580 psi	35 < P < 40 bar 508 to 580 psi	35 < P < 40 bar 508 to 580 psi	35 < P < 40 bar 508 to 580 psi
6.6	Capacity Of Air Receivers	2 x 250 L 2 x 15255 in3	2 x 400 L 2 x 24208 in3	2x(2 x 400 L) 2x2x24408 in3	2x(2 x 500 L) 2x2 x 30510 in3	2x(2 x 400 L) 2x2x24408 in3	2x(2 x 500 L) 2x2 x 30510 in3
6.7	Air Dryer	No	Yes	Yes	Yes	Yes	Yes
7.0	COMBUSTION AIR SYSTEM						
7.1	Combustion Air Filter Type	2 x Dry	2 x Dry	2 x Oil Bath	2 x Dry	2 x Dry	2 x Dry
7.2	Combustion Air Piping	N/A All Engine Mounted	N/A All Engine Mounted	Yes	Yes	Yes	Yes
7.3	Air Intake Suction Max Pressure (total sys.) Clean Filters	200 mm CE 8 in H2O	200 mm CE 8 in H2O	200 mm CE 8 in H2O	200 mm CE 8 in H2O	200 mm CE 8 in H2O	200 mm CE 8 in H2O
7.4	Turbocharger Type Number	BBC VTR 321 2	BBC VTR 321 2	BBC VTR 251 2 x 2	BBC VTR 251 2 x 2	BBC VTR 251 2 x 2	BBC VTR 251 2 x 2

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
7.5	Intake Air Pressure	2.3 +/- 0.3 bar 29 to 38 psi	2.1 +/- 0.3 bar 26 to 34 psi	1.3 +/- 0.3 bar 15 to 23 psi	1.7 +/- 0.3 bar 20 to 29 psi	1.7 +/- 0.3 bar 20 to 29 psi	1.7 +/- 0.3 bar 20 to 29 psi
7.6	Intake Air Temperature	55°C +/- 3°C	56°C +/- 3°C	55°C+/- 3°C	60°C +/- 3°C	60 °C +/- 3 °C	60°C +/- 3°C
7.7	Combustion Air Flow at 30oC / 760 mmHg	9.8 Kg/sec	8.8 Kg/sec	5 Kg/sec +/- 5%	5.2 Kg/sec +/- 5% (41630 lb/hr)	5.2 Kg/sec +/- 5% (41630 lb/hr)	5.2 Kg/sec +/- 5% (41630 lb/hr)
8.0	EXHAUST SYSTEM						
8.1	Exhaust Temperature: After Turbo Before Turbo	 400°C 620°C	 380 °C 570 °C	 440 °C 550 °C	 450°C 600°C	 450°C 600°C	 450°C 600°C
8.2	Exhaust Volume By Temperature	18.7 m3/sec	16.3 m3/sec	10.1 m3/sec	10.7 m3/sec	10.7 m3/sec	10.7 m3/sec
8.3	Exhaust Back Pressure (Total System) Max Allowable	250 mm CE 10 in H2O	250 mm CE 10 in H2O	250 mm CE 10 in H2O	250 mm CE 10 in H2O	250 mm CE 10 in H2O	250 mm CE 10 in H2O
8.4	Silencer Type	Horizontal	Vertical	Vertical	Horizontal	Horizontal	Horizontal
9.0	MISCELLANEOUS						
9.1	Governor Type	EUROPA 1102 Hydraulic Only	EUROPA 1102 Hydraulic Only	BOSCH H20 Hydraulic Only	WOODWARD EGB 35P Electro-Hydraulic	WOODWARD EGB 35P Electro-Hydraulic	WOODWARD EGB 35P Electro-Hydraulic

ENCLOSURE (1)

COMPARISON TABLE

Item	Description	KRUMMEL	EdF CRUAS	ASCO	NSP Prairie Island	YONGGWANG Corée	BG&E Calvert Cliffs
9.2	Auxiliaries Desk	Yes	Yes	Yes 2x	Yes 2x	Yes 2x	Yes 2x
9.3	Allowable Pressure Drop For External Piping & PSI Coding Equipment	0.4 bar 5.8 psi	0.4 bar 5.8 psi	0.4 bar 5.8 psi	0.4 bar 5.8 psi	0.4 bar 5.8 psi	0.4 bar 5.8 psi

ENCLOSURE (2)

KRUMMEL NUCLEAR PLANT TEST PROGRAM SUMMARY

ENCLOSURE (2)

KRUMMEL NUCLEAR PLANT TEST PROGRAM SUMMARY

I. EQUIPMENT DESCRIPTION

A total of six (6) diesel generator set (GEN-SETS) were supplied:

A. Three diesel generator sets, with SACM model UD45V16S5D diesel, each driving a Siemens generator, rated at 6900V, 50 Hz, 1500 rpm, and 3160 KW continuous.

B. Three diesel generator sets, with SACM model UD45V20S5D diesel, each driving a Siemens generator, rated at 6900V, 50 Hz, 1500 rpm, and 4390KW continuous.

II. TEST CRITERIA

Testing was performed according to the German Nuclear requirements which have addressed the IEEE 387 and NRC Regulatory Guides for recommended testing methodology and acceptance criteria.

III. TEST PROGRAM

A. FACTORY TESTING

Standard SACM factory testing for each of the six diesels was performed by SACM prior to shipment to the site. A 100-hour load test of a UD45V20S5D engine was successfully performed. Testing was witnessed by the Bureau Veritas and documented in their report BVAT 0168971B12.

SACM for this particular contract, did not perform any testing of the customer-supplied, SIEMENS generator, or combined GEN-SET testing at the SACM factory.

B SITE TESTING

Site testing verified over 100 hours of load carrying capability on a V20 version diesel generator set per the following loading schedule:

LOAD (%)	DURATION	COMMENT
0	< 10 seconds	Start with manuel loading
100	80 hours	
110	1 hour	
110	2.5 hours	
75	2.5 hours	
50	2.5 hours	
25	2.5 hours	
15	4 minutes	Note 1
100	6 minutes	Note 1
25	4 minutes	Note 2
100	6 minutes	Note 2
50	4 minutes	Note 3
100	6 minutes	Note 3
75	4 minutes	Note 4
100	6 minutes	Note 4

Notes :

1. This 15 to 100 to 15 per cent cycle was repeated 50 times
2. This 25 to 100 to 25 per cent cycle was repeated 50 times
3. This 50 to 100 to 50 per cent cycle was repeated 18 times
4. This 75 to 100 to 75 per cent cycle was repeated 50 times

Throughout this base-load and transient-load demonstration test, no failures occurred.

Multiple start and load tests were conducted by the utility on a V20 GEN-SET as qualification data for all the V16 and V20 versions, in a two phase test program.

1. PHASE A

Testing consisted of engine start, followed by sequenced step- loading with the diesel generator carrying this total load until equilibrium temperatures were reached. Load shed consisted of a reverse in the sequence loading until all load had been removed. The engine was then cooled to the "keep warm" temperature values in 4 hours.

The start-load-unload cycle was repeated over 200 times without a failure of the GEN-SET to accelerate and pickup the step loads applied during the sequence.

After this series of tests, an inspection was performed and no abnormal engine wear was indicated.

2. <u>PHASE B</u>

A. Qualification testing continued on the same GEN-SET. Testing consisted of engine start, followed by sequenced step-loading, with the diesel generator carrying this total load until equilibrium temperatures were reached. Load shed consisted of a reverse in the sequence loading until all load had been removed.

B. With the engine still running, the loads were again sequenced on the diesel generator, held until steady-state occurred, and then removed in a sequenced fashion.

C. This particular scenario (B), with the engine running, was repeated an additional time, for a total of three sequenced loadings per test cycle (A + B + C).

The entire cycle was repeated, after engine cooldown to the "keep warm" temperature values. A total of 400 cycles or 1200 sequence step-loadings were demonstrated during phase B of the testing with no failures of the GEN-SET to start or accept the loads.

Post inspections of the GEN-SET indicated no abnormal engine wear after more than 600 starts and 1400 sequenced step loadings were imposed on the generator.

Acceptance testing per German requirements was conducted on both the V16 and V20 version of the SACM diesel generator sets. The test consisted of 99 hours of continuous load at 100 per cent rating with 1 hour at greater than 110 per cent of generator rating. No failures occurred during this endurance demonstration.

Surveillance testing continues with monthly verification of 100 per cent output capability for a 1 hour period. This monthly testing is concluded with a fast start followed by automatic sequencer loading. Annually, each of the diesel generator sets is tested for 24 hours continuous output of 100 percent followed by an overload of 110 per cent for 1 hour.

ENCLOSURE (3)

EdF-CRUAS NUCLEAR PLANT TEST PROGRAM SUMMARY

EdF-CRUAS NUCLEAR PLANT TEST PROGRAM SUMMARY

I. EQUIPMENT DESCRIPTION

Eight (8) diesel generator sets, with SACM model UD45V20S5D diesel, each driving a Jeumont-Schneider generator, rated at 6900V, 50 Hz, 1500 rpm, 4000 KW continuous.

II. TEST CRITERIA

Testing was performed according to the French Nuclear requirements which have addressed the IEEE 387 and NRC Regulatory Guides for recommended testing methodology and acceptance criteria. In addition the EdF test program the initiated to verify that the problems found in the BUGEY and FESSENHEIM connecting rods had indeed been resolved.

III TEST PROGRAM

A. FACTORY TESTING

Standard SACM factory testing of the diesel, generator, and the combined diesel generator set performance was conducted for each of the above eight GEN-SETS.

An additional diesel generator was built and factory tested to the SACM standards. This ninth diesel generator set became the designated test set used by EdF to establish the qualification for the SACM diesel generator sets.

B. SITE TESTING

A comprehensive test program was conducted at the EdF-CRUAS nuclear plant. The sequence of the testing conducted was as follows:

	STARTS	SUBSEQUENT LOAD / ACTIVITY
PHASE A	14	No-load applied after start.
	1	Step load of 40 per cent applied

Note: The Phase A cycle was repeated 20 times, with 20 engine inspections between repeats, for a total of 300 successfull starts and 20 step-load demonstrations.

	STARTS	SUBSEQUENT LOAD / ACTIVITY
PHASE B	14	No-load applied after start.
	1	Step load of 40 per cent applied

Note: The Phase B cycle was repeated 10 times, with 10 engine inspections between repeats, for a total of 150 successful starts and 10 step-load demonstrations.

PHASE C

The sequence listed in PHASE B above was repeated an additional seven (7) times. The total of successful starts under this test phase equaled 1050, with 70 additional engine inspections and 70 step-load demonstrations.

The total of all of the field tests listed above is computed as follows:

	STARTS	40% STEP LOAD	INSPECTIONS
PHASE A	300	20	20
PHASE B	150	10	10
PHASE C	1050	70	70
TOTAL	1500	100	100

No failures were encountered throughout this rigorous test sequence. Diesel generator start times throughout the testing remained in a range of 7.5 to 8.5 seconds.

The last engine inspection after completion of all testing, did however indicate a modification was required in the symmetrical design of the piston ring spacing, as well as relocation of the uppermost ring on the piston. This change in ring-to-ring spacing and the re-location on the piston has been made to all SACM engines. The inspection further confirms that the previous connecting rod problem at BUGEY and FESSENHEIM had been resolved by SACM.

A report prepared by the EdF utility acknowledges the reliability of these SACM model UD45 engines for nuclear plant application.

ENCLOSURE (4)

ASCO NUCLEAR PLANT TEST PROGRAM SUMMARY

ENCLOSURE (4)

ASCO NUCLEAR PLANT TEST PROGRAM SUMMARY

I. EQUIPMENT DESCRIPTION

Four (4) diesel generator sets, with two (2) SACM model UD45V16S5D diesels, connected in a tandem configuration driving a Jeumont-Schneider generator, rated at 6900V, 50 Hz, 1500 rpm, 4500KW continuous.

II. TEST CRITERIA

Testing was performed according to the Spanish Nuclear requirements which have addressed the IEEE 387 and NRC Regulatory Guides for recommended testing methodology and acceptance criteria. Utilizing the KRUMMEL site tests as a qualification basis, the 300 start with subsequent 50 per cent step-loading tests were not required.

III. TEST PROGRAM

A. FACTORY TESTING.

Standard SACM factory testing of each diesel, generator, and the combined diesel generator set performance was conducted for each of the above tandem-driven GEN-SETS.

Each tandem-driven GEN-SET was tested in accordance with the following test schedule:

STARTS	LOADING	COMMENTS
7	None	Train A Starting Air Receiver capacity
7	None	Train B Starting Air Receiver capacity
1	50%	Sequence loading up to this value
0	106%	From a load plateau of 50%, sequence loading up to 5370 KW
0	146%*	From a load plateau of 4780 KW, sequence loading up to 6580 KW
1	80%	Step-load of 3600 KW applied followed by an 0 38 % additional step load 3 seconds later of 1700 KW
0	+117%	Load reject transient response verified by step 5300 KW load reduction
0	80%	Step-load of 3600 KW applied followed by an 0 38 % additional step load 3 seconds later of 1700 KW
0	+117%	Load reject transient response verified by step 5300 KW load reduction
100	None	Verification of diesel engine start only
TOTAL 116		

* Full load nameplate value. Duration of peak value was 1.5 seconds during final stage of load sequencing.

B. SITE TESTING

Site testing was conducted utilizing the recommendations of the USNRC Regulatory Guide 1.108. Thirty-five (35) valid, consecutive starts, each followed by manuel synchronization to the grid and loading to >50 per cent of generator nameplate, were successfully performed on each GEN-SET with no failures. A total of 140 start-load cycles were successfully completed for this site with four GEN-SETS.

A 24-hour continuous load test was performed on each GEN-SET. The 24-hour capacity test consisted of loading the GEN-SET to the 110 percent of nominal rating for 2 hours, followed by loading to the 100 percent of nominal rating for the remaining 22 hour period.

The GEN-SET transient load capability was established by simulating a safeguards and blackout condition, causing safeguards loads to be sequenced onto the GEN-SET.

Periodic testing of the diesel generator sets, ongoing since 1982 for Unit 1 (1985 for Unit 2), continues in the form of a plant surveillance test program. The program consists of two types of tests conducted at both monthly and annually (refueling outage) intervals.

The monthly test utilizes one of the four different start signals (manual, SI, blackout, or coincident SI + blackout) to initiate a GEN-SET start. The type of signal used is such that each variation is demonstrated at least every 124 days. GEN-SET acceleration together with voltage and frequency (speed) response are monitored during the test. Startup is followed by manual loading to 100 per cent nameplate in 60 seconds and held at that value for a one-hour period.

The refueling outage testing consists of automatic start via a simulated SI or SI + blackout, followed by load sequencer application of safeguards loads. Verification of acceleration, voltage and frequency (speed) is performed at this time. Also demonstrated during this refueling outage test are loss of largest single load response, full-load rejection, and 24-hour load capability.

ENCLOSURE (5)

NSP NUCLEAR PLANT TEST PROGRAM SUMMARY

ENCLOSURE (5)

NSP NUCLEAR PLANT TEST PROGRAM SUMMARY

I. EQUIPMENT DESCRIPTION

Two diesel generator sets, with SACM model UD45V16S5D diesel, each driving a JEUMONT-SCHNEIDER generator, rated at 4160V, 60 Hz, 1200 RPM, 5400 KW continuous.

II. TEST CRITERIA

Testing was performed according to the Nuclear Regulatory Commission, Guide 9, Rev. 2 and the IEEE 387-84.

III. TEST PROGRAM

Standard SACM factory testing was conducted for each of the two conbined diesel generator sets according to the specification DLTC 1604, 21.05.90 (Generating Set Tests).

- Starting and load acceptance tests without circulation of raw cooling water (from 0 to 100% load within approximately 43 sec). Duration : 5 minutes.

A total of 35 startings has been carried out, 30 starts preheated engines, 5 starts with operating equilibrum temperature.

- Capability test: at nominal power (5400 KW, 1200 RPM, 4160 Volts). An endurance test of 22 hours has been carried out.

- Overload test: at 110% of nominal load during 2 hours. Power 5940 KW at 1200 RPM.

- Starting and reloading test: the GEN-SET has been started and reloaded at 110% for 1 hour.

- Test at stable load: These tests were to have the nominal power output of the GEN-SET varying from 0 to 100% and from 100% to 0 in steps of 25% of the nominal power i.e

0 to 25%	load 1350 KW at 1200 RPM
25 to 50%	load 2700 KW at 1200 RPM
50 to 75%	load 4050 KW at 1200 RPM
75 to 100%	load 5400 KW at 1200 RPM

and return.

- Overspeed test : with the GEN-SET idling at 1200 RPM, the speed has been manually increased to its overspeed set point : 1380 ± 27 RPM (± 2%).

ENCLOSURE (6)

YONGGWANG NUCLEAR PLANT TEST PROGRAM SUMMARY

ENCLOSURE (6)

YONGGWANG NUCLEAR PLANT TEST PROGRAM SUMMARY

YGN NUCLEAR PLANT TEST PROGRAM SUMMARY

I. EQUIPMENT DESCRIPTION

Four diesel generator sets, with SACM model UD45V20S5D diesels, connected in a tandem configuration driving a Jeumont-Schneider generator, rated at 4160 V, , 60 Hz, 1200 RPM, 6500 KW continuous.

II. TEST CRITERIA

Testing was performed according to the Korean Nuclear requirements which have addressed the IEEE 387-84 and NRC Regulatory Guides 1.9 for recommended testing methodology and acceptance criteria.

III. TEST PROGRAM

Standard SACM factory testing of each diesel, and the combined diesel generator set performance were conducted for each of the above tandem-driven GEN-SETS. Those tests were established in conformance with applicable Nuclear Standards.
Each tandem-driven GEN-SETS was tested in accordance with SACM's specification DLTC 1772, dated 4.10.91 (class 1 Diesel generator set combined test report).

- Load capability test

These tests are to demonstrate the capability of the Diesel generator Unit to carry the rated loads for the period of time indicated and to successfully reject load.

Program:
. running on no load during 4 hours
. running on 75% load (4875 KW) during 2 hours
. running on 25% load (1625 KW) during 1/2 hour
. running on 50% load (3250 KW) during 1/2 hour
. starting of DG SET, the load has been progressively increased to full load 6500 KW. This load has been maintained 20 minutes in order to reach the temperature equilibrum.
. continuous rated load test: running on continuous rated load (6500 KW) during 22 hours.
. Short Time Rating Test: running on short time rating at 7150 KW (110% of load) during 2 hours.
. Short Time Rating Load rejection Test: At the end of the load sequence tests, the load rejection test has been performed by sudden unloading of 7150 KW. This test has been made with the electric governor.
During the rejection test the speed, voltage and load have been recorded.
GEN-SET speed must not increase more than 75% of the difference between nominal speed and the overspeed trip set point (1380 RPM) or 180 x 0.75 = 135 RPM.
The result is an increase in speed of 45RPM, lower than 135 RPM. Therefore the requirement of IEEE 387 is satisfied.

- Margin tests:
The aim of this test is to demonstrate the Diesel Generator capability to start and carry loads that are greater than the magnitude of the most severe step load within the plant design load profile.
Reference: IEE 387,84 para 7.2.3
SACM procedure DLTC 1575 - para 9.4
SACM calculation Note DLCL 13.1.987 para 3.4.2.

- Load sequence tests:
The aim of this test is to establish the capability of the Diesel Generator Unit to accept the specified sequence loads.
Reference:
Specification: - 9.165M896 Para 4.05.B
- MSS 21-5 Para 9.11
- SACM procedure DLTC 1575 para 9.5
- SACM calculation note DLCL 13.1.1987 para 3.4.1
Test process: Eight load steps corresponding to the complete specified load sequence have been performed. For each the test has been carried out twice: once with electric governor and once with hydraulic governor.

- Overspeed Tests:
The aim of these tests is to verify the calibration and the functioning of the four pneumatic overspeed devices. With the genset idling at 1200 RPM, the speed has been manually increased to its overspeed set point: 1400 RPM or to within ± 30 RPM to trip the genset.

- 300 start tests :
A total of 300 valid start and loading tests has been performed for the qualification of one of the four Diesel Generators set delivered to the Nuclear Power Plant of Yonggwang (Unit3-4). This test was made in accordance with the requirements fo IEEE 387-84 - Chapter 7.2.2 Start and Load Acceptance Tests

The Combined Tests of the diesel generator have been performed and are in conformity with the applicable specification 9-165 M 896 or with the IEEE standard 387,84.

ENCLOSURE (7)

SACM ENGINEERING EVALUATIONS

ENCLOSURE (7)

SACM ENGINEERING EVALUATIONS

The purpose of this review is to discuss single and tandem configured GEN-SET response during various phases of operation, including: starting, loading, and steady-state load operation. Information presented here is based on test results of single GEN-SETS at KRUMMEL and CRUAS nuclear plants, in-service results of tandem GEN-SETS at ASCO, VANDELLOS, KOREAN (YNG) and NSP Prairie Island nuclear plants, and SACM calculations.

I. STARTING PHASE

A. AIR START SYSTEM

Air start system components of the SACM model UD45 engine, and their designed function are identical for each configuration. The tandem design differs only in the amount of conservatism with the addition of another redundant starting air system, enabling GEN-SET start from any two of four air supplies.

The starting failure rate of a single GEN-SET is approximately 0.36×10^{-4} per start request, as determined by the actual failure rate experienced in the field. Since a tandem configured GEN-SET, with its redundant starting air system, could be considered to have half this failure rate, a value of 0.18×10^{-4} can be initially assigned to the tandem GEN-SETS. However, a risk assessment calculation assigns an additional 0.04×10^{-4} per start request due to considerations of starting air system common mode failures. Thus the total calculated starting failure rate for a tandem configured GEN-SET is 0.22×10^{-4} per start request.

B. FUEL INJECTION SYSTEM

On UD45 engines, engine start and load control is regulated by a governor. The governor, in response to deviation from a nominal speed setpoint physically positions the fuel rack to uniformly permit the fuel injection pump of each cylinder to supply the appropriate amount of fuel. Maximum deviation occurs upon receipt of a start signal with the engine at zero speed, causing full opening of the fuel racks.

Pneumatic booster is provided to overcome the inherent lag in governor hydraulic pressure output during engine starting. The booster, utilizing starting air system as a pressure source, pressurizes the hydraulic output portion of the governor to provide the instantaneous opening of the fuel racks.

Both the KRUMMEL and BG & E designs incorporate the use of this pneumatic booster assembly to establish maximum fuel position at the time of engine start.

At the moment of start, there is no functional difference in the control of the fuel injection system between the KRUMMEL and BG & E engine.

C. ENGINE IGNITION

The engine speed at which auto-ignition takes place inside the cylinder (engine ignition) depends essentially upon the engine volumetric compression ratio and combustion air temperature.

The two engines of the BG & E tandem GEN-SET design have exactly the same volumetric compression ratio and combustion air temperature at aspiration. Engine ignition therefore occurs at the same shaft speed, approximately 75 rpm. No detrimental interaction between engines occurs even in the event of a slight shift in ignition speed. Either engine will provide sufficient acceleration to increase the shaft speed sufficiently to cause engine ignition of the remaining engine.

D. ELASTIC COUPLINGS

When the auto-ignition speed is attained, each of the two engines of a tandem GEN-SET provide essentially the same torque. This output torque equality is based on the fact that each engine has: 1) an identical number of cylinders; 2) with equivalent displacement; 3) maximum fuel rack positioning; 4) identical turbocharging; and 5) the same thermodynamic conditions in each cylinder. Each engine-to-generator coupling therefore, transmits an equal amount of torque to initially rotate the generator.

E. STARTING INERTIA

Two key factors in determining the starting time of a GEN-SET are the Starting Inertia and the RPM plateau which the GEN-SET must achieve to become synchronous. For the model UD45 engines, the 60 Hertz synchronous speed is 1200 rpm, while for 50 Hertz operation, the synchronous speed is 1500 rpm.

SITE	TYPE SET	UD45 ENGINES	SYNCH SPEED (rpm)	GLOBAL ROTATING INERTIA ($kg-m^2$)	INERTIA PER CYL ($kg-m^2$)	MEASURED START TIME (seconds)
KRUMMEL	Single	V20S5D	1500	590.7	27.5	7.5 to 7.7
CRUAS	Single	V20S5D	1500	646.3	32.3	7.7 to 8.0
NSP	Tandem	V16S5D	1200	1246.7	39.0	7.2 to 8.3
ASCO	Tandem	V16S5D	1500	1459.0	45.6	< 10
CHINA	Tandem	V12S5D	1500	864.5	36.0	8.3 to 8.5
YONGWANG	Tandem	V20S5D	1200	1357.5	33.9	5.4 to 6.1
BG&E	Tandem	V16S5D	1200	1191.9	37.24	8.0 (calculated)

F. CONCLUSIONS

During the starting phase, a side-by-side comparison of a tandem GEN-SET and two single GEN-SETS may be made, on the condition that the engines are of the same model design and that the operation of the starting air system and governor are functionallly the same. Under these conditions, the results of starting tests conducted on a single-engine GEN-SET engines at the KRUMMEL plant and those for the BG & E plant can be compared in this fashion.

II. OPERATING PHASE

A. LOAD ACCEPTANCE

The engine response time to load changes depends primarily on the governor response and the performance of the turbocharging system.

From a theoretical point of view, SACM has shown by calculation that the BGE GEN-SET is capable of satisfying the transient speed criteria, experienced during step-loading and loss-of-load situations. The calculation program utilized by SACM since 1976, has been proof-tested with resulting high reliability and repeatability in predicting GEN-SET performance on numerous nuclear and non-nuclear installations.

In application however, the overall response of the GEN-SET during a given transient condition is subject to the following component responses:

1) When there is a large increase in load demanded by the generator, as during the initial loading phase, the speed of the GEN-SET drops and the governor responds nearly instantly (within approximately 100 milli-seconds), to this speed variation. The governor places the fuel injection pumps in full rack position. Therefore, all of the cylinders receive, during this transition phase, the same quantity of fuel. The differences in the reaction times of the two governors are less than 0.5 per cent. The differences in load regulation of the power at full rack are also less than 0.5 per cent.

2) During this transient load time, the turbochargers receive the same energy from the exhaust gas and due to there identical design, they furnish the same amount of turbocharging (combustion air boost) pressure to each of the two engines. Difference in turbocharging pressure for a given exhaust gas value, caused by fouling and/or inherent component tolerance differences, decreases the instantaneous power response between the two engines by less than 2.0 per cent.

The effective cumulative differences, due to governor and turbocharger response are significantly offset by providing a total fuel rack travel equivalent to 115.6 per cent of nominal full power.

B. STEADY-STATE

Two important aspects of stability at steady-state consist of speed stability and engine-to-engine load division (sharing). Discussion of these two areas is provided below:

1. SPEED STABILITY

Engine speed stability depends essentially on the performance of the governing system. When considering only the hydraulic portion of the governor units provided at KRUMMEL and BG & E, speed stability performance is identical.

The BG & E choice of the Woodward model EGB35P governor with mode 2301A processor however, greatly enhances the overall system response with the introduction of an electronic speed control system as the primary control element. The hydraulic section of the governor performs a dedicated backup function, with a nominal setpoint of 1245 rpm to permit a sufficient maneuvering range for the electronic system corrections required to maintain the desired 1200 rpm setpoint value.

2. LOAD SHARING

A. GOVERNOR

The discussion of load sharing as presented here pertains to the engine-to-engine load sharing as seen in a tandem GEN-SET configuration. In the past, SACM had utilized a pneumatic load sharing system (e.g. ASCO and ALMARAZ) which controlled the hydraulic governing system satisfactorily. Expressed in terms of power of one engine compared to the other, the difference is, at the nominal rating, on the order of 3.5 to 4.0 per cent.

The tandem GEN-SETS of South Korea, Units 9 & 10, are equipped with a system of electric load sharing. The precision obtained in terms of the difference in power is on the order of 3.0 to 3.5 per cent.

The tandem GEN-SETS of VALDECABALLEROS and BG & E are equipped with an electronic load-share compensation system. The precision in load sharing with this particular type of system is on the order of 3.0 to 3.5 per cent at the nominal rating. All things being otherwise equal, this is the expected range for the BG & E GEN-SETS.

The above load-share differences are again significantly offset by the 115.6 per cent full fuel injection capability of each engine.

b. ELASTIC COUPLINGS

For the BG & E tandem GEN-SETS, the maximum torque that is transmitted to each coupling in 26.000 mN (newton-meters). The nominal torque of the coupling which SACM has chosen for these GEN-SETS Stromag,(i.e type GEF 2900 R) is 20.000 mN, with a maximum torque capability of 87.000 mN. Consequently, the differences in torque value between each engine, as a result of load sharing tolerances, the order of 3.0 to 3.5 per cent, are well within the coupling design margin.

c. TORSIONAL VIBRATIONAL

SACM has addressed the torsional vibration responses for the tandem GEN-SET under the following postulated scenarios:

1) Two engines operating in overload (i.e. short time rating)

2) One engine driving the entire shaftline, including the second engine which is providing no torque. In this case, the power of the tandem GEN-SET is reduced by 50 per cent.

3) Single engine operation with the second engine having been uncoupled. In this case, the power of the tandem GEN-SET is reduced by 50 per cent.

In all of the above postulated configurations, the torsional vibrations were calculated and found to be within acceptable limits. The calculation of torsional vibration being performed will verify that no harmful vibration occurs within plus or minus ten percent of the idle speed or within plus or minus five percent of the synchronous speed, as required by IEEE-387 (1984), paragraph 5.5.1.2.

C. CONCLUSIONS

A tandem GEN-SET may be directly compared to a single GEN-SET with the condition that the governing systems are the same on each of the engines and that a load sharing device corrects for the small differences between each engine governor response. The precision in terms of power on each engine is on the order of 3.0 to 3.5 per cent at the nominal power rating.

SACM model UD45 engines have shown a high operational reliability with values on the order of 0.74×10^{-3}/hour failure rate for single GEN-SETS and a 1.25×10^{-3}/hour failure rate for tandem configured GEN-SETS.

Tests previously conducted on both single and tandem GEN-SETS of the same base model design (UD45), have adequately established the qualification of the tandem GEN-SETS to be utilized at BG & E. The SACM engineering evaluation presented here coupled with the other test and field experience of the UD45 engines (presented elsewhere in this report) and the proposed test demonstration programs to be conducted in the factory and at the site, support the reduction in test starts and the acceptance of this engine design as having been previously qualified.