ENCLOSURE 1 TO NL-12-097

IP-CALC-11-00058, "IP3 EMERGENCY DIESEL GENERATOR (EDG) FUEL OIL CONSUMPTION LICENSING BASIS CALCULATION," REV 1.

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

☐ ANO-1	☐ ANO-2	☐ GGNS	☐ IP-2	☒ IP-3	☐ PLP
☐ JAF	☐ PNPS	☐ RBS	☐ VY	☐ W3	
☐ NP-GGNS-3	☐ NP-RBS-3				

CALCULATION COVER PAGE	**EC #** 32406	**Page 1 of** 25

Design Basis Calc. ☒ YES ☐ NO	☒ CALCULATION ☐ EC Markup

Calculation No: IP-CALC-11-00058	**Revision: 1**
Title: IP3 Emergency Diesel Generator (EDG) Fuel Oil Consumption Licensing Basis Calculation	**Editorial** ☐ YES ☒ NO

System(s): EDG (Fuel Oil System)	**Review Org (Department):** Design Engineering Mechanical	
Safety Class: ☒ Safety / Quality Related ☐ Augmented Quality Program ☐ Non-Safety Related	**Component/Equipment/Structure Type/Number:**	
	DE-31	
	DE-32	
	DE-33	
Document Type: CALC	EDG-31-FO-STNK	
Keywords (Description/Topical Codes): Fuel Oil; Consumption; EDG	EDG-32-FO-STNK	
	EDG-33-FO-STNK	

REVIEWS

Name/Signature/Date	Name/Signature/Date	Name/Signature/Date
J. P. Bubniak 2/7/12	J. Bencivenga 2/7/12	V. E. Myers 2/8/12
Responsible Engineer	☒ **Design Verifier** ☐ **Reviewer** ☐ Comments Attached	**Supervisor/Approval** ☐ Comments Attached

CALCULATION REFERENCE SHEET	CALCULATION NO: **IP-CALC-11-00058** REVISION: 1

I. EC Markups Incorporated (N/A to NP calculations)

1. 32406
2.
3.
4.
5.

II. Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	Tracking No.
1. IP3-CALC-ED-00207	N/A	8	☒	☐	N	N/A
2. Tech Spec Basis 3.8.1	N/A	N/A	☒	☐	N	N/A
3. Tech Spec Basis 3.8.3	N/A	N/A	☒	☐	N	N/A
4. Tech Spec 5.5.12.a	N/A	N/A	☒	☐	N	N/A
5. Duke Prod 9321-01-102-1	N/A	N/A	☒	☐	N	N/A
6. Report MPR-2980	N/A	0	☒	☐	N	N/A

III. CROSS REFERENCES:

1. See Section 11.0 of calculation for applicable references.
2.
3.
4.

IV. SOFTWARE USED: None

Title: N/A Version/Release: N/A Disk/CD No. N/A

V. DISK/CDS INCLUDED: None

Title: N/A Version/Release N/A Disk/CD No. N/A

VI. OTHER CHANGES: None

Revision	Record of Revision
0	Initial issue.
1	The following items were added to the scope of the calculation: A. Three additional fuel oil consumption cases were evaluated: 1. Three EDGs operating continuously for 7 days. 2. Two EDGs operating continuously for 6 days. 3. Three EDGs operating continuously for 6 days. B. Consumptions of fuel oil of specific gravity greater than 0.83, up to 0.89, were evaluated for applicable EDG operating cases. C. Consumptions of fuel oil in 48 hours and 7 days were determined with EDG operation at 100% rated capacity (1750 kW) throughout the timeframes.

Table of Contents

5.0 Purpose

The primary purpose of this calculation is to determine the amount of fuel oil that would be consumed by the IP3 EDGs operating at the EDG 24 hour maximum loading profile for the 48 hour and 7 day periods currently cited in Technical Specification Basis 3.8.3 [Ref 3]. A secondary purpose is to determine the maximum volumetric fuel oil consumption rate of an EDG operating at a loading of 1750 kW. The results of this calculation will be used as input to establish the EDG fuel oil quantities required to be stored in the EDG Fuel Oil Storage Tanks (FOSTs) and in the reserve tank(s) on site.

Revision 1 was undertaken in response to issues related to proposed future Licensing Basis Document changes. One of the purposes of this Revision is to add the following fuel oil consumption cases to those already evaluated in Revision 0:

1. Three EDGs all operating continuously for an entire 7 day period.
2. Two EDGs all operating continuously for an entire 6 day period.
3. Three EDGs all operating continuously for an entire 6 day period.

Another purpose of Revision 1 is to determine the consumptions of fuel oil of specific gravity greater than the minimum 0.83, up to 0.89, for applicable EDG operating situations.

Lastly, Revision 1 determines the fuel oil consumptions of the EDGs in 48 and 168 hours (7 days) assuming operation at the 100% rated capacity (1750 kW) throughout the subject time periods. In these determinations, no conservatisms are added to account for uncertainties in fuel oil mass usage during initial ALCO diesel testing and for potential effects of Ultra Low Sulfur Diesel (ULSD) on fuel oil heat values.

Background

During the IP3 NRC Component Design Basis Inspection (CDBI) occurring in October 2010, an issue tracked as CDBI Item #99 was raised regarding the accuracy of the Emergency Diesel Generator (EDG) fuel oil usage section of IP3-CALC-EG-00217 Rev 4 [Ref 1]. It was noted that certain inputs that could play a role in the magnitude of EDG fuel oil consumption were not included in the current version of the calculation. The NRC concerns were documented in CR-IP3-2010-03088 [Ref 2]. Furthermore, discussions with an MPR Associates expert on diesel fuel combustion [Ref 9] conducted subsequent to the issuance of the Condition Report confirmed that determination of useable volumes of EDG fuel oil are to be based on the low (net) heat value of the fuel oil. In addition, it must be noted that the current requirement to use Ultra Low Sulfur Diesel fuel oil for EDG operation may also introduce an effect on useable volume determination as explained in Reference 7.

To formally address the CR-IP3-2010-03088 and fuel oil heat value issues, IP-CALC-11-00011 [Ref 11] was generated to calculate EDG fuel oil consumptions for the accidents / transients evaluated in IP3 EDG Loading Study IP3-CALC-ED-00207 [Ref 8]. The EDG

loading profile inputs in IP-CALC-11-00011 were derived from a technically justifiable combination of Reference 8 and Plant Simulator information pertaining to the individual accident / transient being evaluated. The specific loads and the EDG operating durations at these loads varied among the events. The Large Break LOCA, the Small Break LOCA, the Main Steam Line Break, and the Steam Generator Tube Rupture each had a different overall EDG loading profile. Based on the results of IP-CALC-11-00011, it was concluded that the EDG fuel oil usable volumes cited in Technical Specification 3.8.3 were non-conservative. CR-IP3-2011-03960 [Ref 12] was written to document this finding.

Investigation performed in response to CR-IP3-2011-03960 concluded that the existing procedurally controlled required fuel oil storage volumes, both for the Fuel Oil Storage Tank and the reserve tank, were sufficient to meet the fuel oil consumption requirements of the EDGs as determined in Reference 11. Therefore, no current EDG operability issue was identified. However, it has been recognized that the non-conservative Technical Specification issue has to be resolved in a timely manner, and the determination of applicable bounding usable volumes of EDG fuel oil is a necessary first step in this resolution process.

6.0 Results

Note: All fuel oil consumption values determined in Section 10 of this calculation have been rounded upward to the nearest whole gallon in this Results Section.

6.1 Maximum volumetric fuel oil consumption of an EDG operating at its 100% rated capacity (1750 kW) for 48 hours, with *no conservatisms added* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	48 Hr 1 EDG Consumption (gallons)
0.8300	6257

6.2 Maximum volumetric fuel oil consumptions of one, two, and three EDGs operating at the 100% rated capacity (1750 kW) every day for 7 days , with *no conservatisms added* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	7 Day 1 EDG Consumption (gallons)	7 Day 2 EDG Consumption (gallons)	7 Day 3 EDG Consumption (gallons)
0.8300	21,900	43,800	65,700

6.3 The following are the Specific Gravity - dependent volumetric fuel oil consumptions of an EDG operating at the 24 hour maximum loading profile for 48 hours, with

conservatisms included for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	48 Hr 1 EDG Consumption (gallons)
0.8300	6840
0.8348	6799
0.8448	6718
0.8550	6638
0.8654	6560
0.8762	6480
0.8871	6396
0.8900	6376

6.4 The following are the Specific Gravity – dependent volumetric fuel oil consumptions of two EDGs operating at the 24 hour maximum loading profile every day for 7 days, with *conservatisms included* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	7 Day 2 EDG Consumption (gallons)
0.8300	47,878
0.8348	47,592
0.8448	47,025
0.8550	46,467
0.8654	45,919
0.8762	45,357
0.8871	44,771
0.8900	44,631

6.5 The following are the Specific Gravity - dependent volumetric fuel oil consumptions of two EDGs operating at the 24 hour maximum loading profile every day for 6 days, with *conservatisms included* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	6 Day 2 EDG Consumption (gallons)
0.8300	41,038
0.8348	40,794
0.8448	40,307
0.8550	39,829
0.8654	39,360
0.8762	38,877

0.8871	**38,375**
0.8900	**38,255**

6.6 The following are the Specific Gravity – dependent volumetric fuel oil consumptions of three EDGs operating at the 24 hour maximum loading profile every day for 7 days, with *conservatisms included* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	7 Day 3 EDG Consumption (gallons)
0.8300	**71,817**
0.8348	**71,388**
0.8448	**70,536**
0.8550	**69,700**
0.8654	**68,879**
0.8762	**68,035**
0.8871	**67,157**
0.8900	**66,946**

6.7 The following are the Specific Gravity – dependent volumetric fuel oil consumptions of three EDGs operating at the 24 hour maximum loading profile every day for 6 days, with *conservatisms included* for ALCO testing result uncertainties and ULSD heat value effects:

Fuel Oil Specific Gravity	6 Day 3 EDG Consumption (gallons)
0.8300	**61,557**
0.8348	**61,190**
0.8448	**60,460**
0.8550	**59,743**
0.8654	**59,039**
0.8762	**58,316**
0.8871	**57,563**
0.8900	**57,383**

6.8 The following is the maximum volumetric fuel oil consumption rate of an EDG operating at a loading value of 1750 kW, with *conservatisms included* for ALCO testing result uncertainties and ULSD heat value effects:

- **141 gallons/hour**

7.0 Input and Design Criteria

1. Design Input No. 1 [Value from Ref 4]

   EDG loading at 100% nominal rated capacity:
   1750 kW

2. Design Input No. 2 [Values from Ref 4 as modified and clarified]:

   The EDG 24 hour maximum loading profile:

   ½ hour at 2000 kW (114.3% of nominal rated capacity)
   2 hours at 1950 kW (111.4% of nominal rated capacity)
   21.5 hours at 1750 kW (100.0% nominal rated capacity)

3. Design Input No. 3 [Values from Ref 6, 13]:

   Specific Gravity values of fuel oil that are explicitly evaluated in this calculation:
   SG = 0.8300; 0.8348; 0.8448; 0.8550; 0.8654; 0.8762; 0.8871; 0.8900

4. Design Input No. 4 [Values from Ref 7 as determined within calc Section 10.1]:

   Mass and volumetric net heat values of "reference" fuel oil (ie, non-ULSD) of the specific gravities listed in Design Input No. 3 above:
   See Table 10.1 – 1 in Section 10.1 of calculation.

5. Design Input No. 5 [Values from Ref 7 as determined within calc Section 10.1]:

   Mass and volumetric net heat values of ULSD fuel oil of the specific gravities listed in Design Input No. 3 above:
   See Table 10.1 – 2 in Section 10.1 of calculation.

8.0 Assumptions

No assumptions are made in the performance of this calculation.

9.0 Method of Analysis

General Design Criterion (GDC) 17, "Electrical Power Systems", of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10CFR Part 50 requires that an on-site electrical power system and an offsite electric power system be provided to permit functioning of structures, systems, and components important to safety. Although IP3 received its operating license from the NRC prior to the General Design Criteria being

finalized, it had committed to meeting the intent of the draft GDC. At IP3, the Emergency Diesel Generators (EDGs) represent the on-site electrical power supply source satisfying the intent of GDC 17.

US NRC Regulatory Guide 1.137 Rev 1, "Fuel Oil Systems for Standby Diesel Generators", was issued in October 1979 and included an approach that was acceptable to the NRC staff for complying with the Commission's regulations regarding fuel oil systems for standby diesel generators, ie, the EDGs at IP3. With respect to calculating fuel oil storage requirements, the Regulatory Guide specifically refers to ANSI Standard N195-1976, "Fuel Oil Systems for Standby Diesel Generators". Section 5.4 of this Standard provides two methods for determining required fuel oil volume:

1.) Calculations based on the assumption that the diesel generator operates continuously for 7 days at its rated capacity.

OR

2.) Calculations based on the time-dependent loads of the diesel generator. For this latter method, the minimum required capacity should include the capacity to power the engineered safety features.

The method chosen for this IP3 fuel oil usage determination is the ANSI N195 Method 1.

The Method 1 calculation is performed with each individual EDG operating at its 100% rated load capacity of 1750 kW for 48 hours and for 168 hours (7 days).

To obtain conservative results, this calculation is also performed with each individual EDG operating at its maximum permissible 24 hour loading profile every day for up to seven days.

The 24 hour maximum load profile for the IP3 EDGs that is used in the conservative approach is the following:

½ hour at 2000 kW (114.3% of nominal rated capacity)
2 hours at 1950 kW (111.4% of nominal rated capacity)
21.5 hours at 1750 kW (100.0% of nominal rated capacity)

When the operating period being evaluated is less than a full day (<24 hrs), only the time of operation at the lowest loading is reduced as this is conservative for determination of the total fuel oil consumed in the overall specified period of time. For this evaluated situation, the operating time at 1750 kW would thus be less than 21.5 hours.

The loading profile stated above differs from the EDG load profile and ratings cited in Technical Specification Basis B3.8.1 [Ref 4]. The Bases state that if the EDG is operated at 2000 kW for ½ hour in 24 hours, then for the remaining time, 23.5 hours, the loading must be limited to 1750 kW or less. The 24 hour maximum loading profile presented

above is conservative for determination of fuel oil usage as it over-estimates the EDG run time at loading of over 1750 kW.

Original ALCO test data of fuel oil usage by the engines installed at IP3, shown in Attachment 2 [Ref 5], provides documentation of the mass consumption in pounds per hour of the EDGs at applicable kW loading values. To permit the extraction of a mass consumption rate corresponding to any kW value within the range of 0 kW to 2000 kW, the Attachment 2 test data was inputted into an EXCEL Spreadsheet. The test data (lb/hr vs kW) was found to closely follow a linear relationship. The Spreadsheet was utilized to graph this relationship for each EDG and a table of lb/hr versus kW values was extracted using the derived curve equation. The graphs and related Table are contained in Attachment 1.

To account for any inaccuracy in the values of the mass consumption data due to EXCEL Program data fit and/or diesel testing methodology uncertainty, the values used in the conservative calculation are increased by 5%. This is deemed to be more than an adequate margin addition to ensure conservative fuel oil usage results since the test data were obtained under controlled conditions. In both the Method 1 and conservative calculation, the ALCO test data pertaining to the highest consuming EDG (# 32) is utilized. A specific fuel usage value represents the total fuel mass consumed per time interval in running the EDG at a defined load, including the amount necessary to lubricate the EDG fuel injector (rack) pump. The mass consumption rates are then utilized to calculate the total pounds of fuel used. This is done by multiplying the rates by the pertinent EDG run time at either 1750 kW or at the kW loads defined in the 24 hour maximum load profile. The result is then used to calculate the total energy in Btu. To determine the bounding required volumetric quantity of fuel oil, the energy content of the lowest specific gravity fuel oil allowed by Technical Specification 5.5.12.a as implemented through Reference 6 is used in the calculation. This limiting specific gravity is **0.83**. However, since TS 5.5.12.a permits fuel oil of specific gravity up to **0.89** to be used in the EDGs, volumetric quantities of fuel oil consumption are determined for specific gravities between 0.83 and 0.89.

Once the total energy in Btu is known, the gallons of fuel oil required to provide this energy is calculated by dividing the energy term by the applicable fuel oil heat value (Btu/gallon). According to Report MPR-2980 [Ref 7] Table 4-2, included in this calculation as Attachment 3, the mass- and volumetric-based heat values of diesel fuel oils relate directly to fuel oil specific gravity. Hence, incorporating the lowest allowed specific gravity into the calculation obtains the greatest volume of fuel oil required. At specific gravities higher than 0.83, the volume of fuel oil required decreases.

For determination of limiting EDG volumetric fuel oil usages, the low heat, or net heat of combustion, data in Table 4-2 are applicable. These mass and volume Btu values represent the net energy available in the fuel oil for the EDGs to perform work. The heat released from the condensing of the water inherently present in the fuel oil does not contribute to EDG work [Ref 9] nor does the fuel oil consumed in lubricating the EDG fuel injection (rack) pump.

Reference 7 evaluated the impact of meeting the Ultra Low Sulfur Diesel (ULSD) rule on the EDG fuel oil heat values described above. It found that in general the heat value of ULSD fuel oil of a certain density was near or exceeded that stated in Table 4-2. However, a minority of the samples of ULSD fuel that were evaluated exhibited a heat value slightly less than the corresponding Table 4-2 reference value. For the Method 1 calculation, the reference heat values for SG 0.83 fuel oil are used. The conservative calculation accounts for the few lower than reference heat values of ULSD fuel by appropriately adjusting the mass and volumetric heat values in the direction that maximizes volumetric fuel oil consumption. See calculation section 10.1 below for details of how ULSD fuel oil effect on heat values is addressed.

10.0 Calculation

10.1 Determination of Mass and Volumetric Fuel Oil Heat Values

In accordance with Tech Spec 5.5.12.a, the relative density of diesel fuel oil acceptable for utilization by the EDGs at IPEC must be in the specific gravity (SG) range of 0.83 to 0.89. A specific gravity of **0.83** correlates to the lowest allowable energy content; therefore, it is appropriate to use this SG value in determining the bounding required fuel oil volume. For specific gravity values above 0.83, up to **0.89**, the required volumes will be less than the calculated bounding volume since the denser fuel oils have progressively higher energy content.

Table 4-2 of Reference 7 (see Attachment 3) contains high and low heat values of typical diesel fuel oils. This Table does not explicitly provide a row of data for fuel oil of specific gravity of 0.83 and 0.89. However, linear interpolation of the data in the Table above and below these specific gravities is an acceptable method to obtain the necessary information because the Btu/lb and Btu/gallon values vary linearly with SG within the interval of interest. The mass and volumetric heat values at specific gravities of 0.83 and 0.89 are determined below. Also provided in this Section of the calculation are mass and volumetric heat values for the specific gravities presented in Table 4-2 lying between 0.83 and 0.89.

Specific Gravity **0.83** Fuel Oil Mass Heat Value (Btu/lb)

0.8251	18,510
0.8300	X_1
0.8348	18,460

$$\frac{0.8348 - 0.8300}{0.8348 - 0.8251} = \frac{18{,}460 - X_1}{18{,}460 - 18{,}510}$$

$$\frac{0.0048}{0.0097} = \frac{18{,}460 - X_1}{-50}$$

$-0.24 = 179.062 - 0.0097X_1$
$0.0097X_1 = 179.302$

$X_1 = 18{,}484.7$ Btu / lb

Specific Gravity **0.83** Fuel Oil Volumetric Heat Value (Btu/gal)

0.8251 127,300
0.8300 Y_1
0.8348 128,500

$$\frac{0.8348 - 0.8300}{0.8348 - 0.8251} = \frac{128{,}500 - Y_1}{128{,}500 - 127{,}300}$$

$$\frac{0.0048}{0.0097} = \frac{128{,}500 - Y_1}{1200}$$

$5.76 = 1246.45 - 0.0097Y_1$
$0.0097Y_1 = 1240.69$

$Y_1 = 127{,}906.2$ Btu / gal

Summary of SG **0.83** Results:

- Mass Heat Value = 18,484.7 Btu / lb
- Volumetric Heat Value = 127,906.2 Btu / gal

Specific Gravity **0.89** Fuel Oil Mass Heat Value (Btu/lb)

0.8871 18,190
0.8900 X_2
0.8984 18,130

$$\frac{0.8984 - 0.8900}{0.8984 - 0.8871} = \frac{18{,}130 - X_2}{18{,}130 - 18{,}190}$$

$$\frac{0.0084}{} = \frac{18{,}130 - X_2}{}$$

0.0113 -60

$-0.504 = 204.869 - 0.0113X_2$
$0.0113X_2 = 205.373$

$X_2 = 18{,}174.6$ Btu / lb

Specific Gravity **0.89** Fuel Oil Volumetric Heat Value (Btu/gal)

0.8871 134,600
0.8900 Y_2
0.8984 135,800

$$\frac{0.8984 - 0.8900}{0.8984 - 0.8871} = \frac{135{,}800 - Y_2}{135{,}800 - 134{,}600}$$

$$\frac{0.0084}{0.0113} = \frac{135{,}800 - Y_2}{1200}$$

$10.08 = 1534.54 - 0.0113Y_2$
$0.0113Y_2 = 1524.46$

$Y_2 = 134{,}908.0$ Btu / gal

Summary of SG **0.89** Results:

- Mass Heat Value = 18,174.6 Btu / lb
- Volumetric Heat Value = 134,908.0 Btu / gal

Table 10.1 – 1: Mass and Volumetric Net Heat Values for Fuel Oil of Specific Gravities Between 0.83 and 0.89 as Determined Above by Linear Interpolation and as Specifically Listed in Table 4-2 of Reference 7

Specific Gravity	Mass Heat Value (Btu/lb)	Volumetric Heat Value (Btu/gallon)
0.8300	18,484.7	127,906.2
0.8348	18,460.0	128,500.0
0.8448	18,410.0	129,700.0
0.8550	18,360.0	130,900.0
0.8654	18,310.0	132,100.0
0.8762	18,250.0	133,300.0
0.8871	18,190.0	134,600.0
0.8900	18,174.6	134,908.0

As of December 2010 [Ref 10], all diesel fuel oil produced domestically for non-road use (ie, in the EDGs and other diesels at IPEC) and supplied to IPEC had to meet the Ultra Low Sulfur Diesel (ULSD) standard in which the sulfur concentration within the fuel oil must be held to 15 ppm or less. An evaluation of the utilization of ULSD fuel oil for EDG operation was performed in 2006 as documented in Reference 7. The evaluators found that the heat values of a set of randomly selected samples of ULSD oil were generally higher at a given density than the reference values presented in Table 4-2. However, there were a few tested cases where ULSD oil heat values were as much as 1.14% lower than the reference values. To maintain conservatism in the determination of the bounding fuel oil quantities required to operate the IP3 EDGs, the mass and volumetric heat values cited in the table above are appropriately adjusted by 1.5%. To obtain the maximum requisite volume, the mass heat value is increased by 1.5% while the volumetric heat value is decreased by 1.5%. An example of this heat value adjustment process applied to fuel oil of SG 0.83 is shown below:

SG 0.83 Fuel Oil Net Heat Values Adjusted for ULSD Fuel

- Mass Heat Value = 1.015 x 18,484.7 = **18,762.0 Btu / lb**
- Volumetric Heat Value = 127,906.2 – (127,906.2 x 0.015) = **125,987.6 Btu / gal**

Table 10.1 – 2: Mass and Volumetric Net Heat Values for Fuel Oil of Specific Gravities Between 0.83 and 0.89 Adjusted Conservatively for ULSD Content

Specific Gravity	Mass Heat Value (Btu/lb)	Volumetric Heat Value (Btu/gallon)
0.8300	18,762.0	125,987.6
0.8348	18,736.9	126,572.5
0.8448	18,686.2	127,754.5
0.8550	18,635.4	128,936.5
0.8654	18,584.7	130,118.5
0.8762	18,523.8	131,300.5
0.8871	18,462.9	132,581.0
0.8900	18,447.2	132,884.4

10.2 Method 1 Determination of Fuel Oil Usage in 48 Hours of EDG Operation [100% Rated Capacity Run with Testing and ULSD Heat Value Conservatisms NOT Included]

From the Reference 5 certified test data, EDG 32 (Serial Number 9735) consumes the greatest amount of fuel oil mass relative to a specific loading value. Therefore, it is appropriate to use EDG 32 consumption data for this calculation. As mentioned in the Method of Analysis section (9.0), for the Method 1 calculation the mass consumption values from the ALCO EDG testing are not increased by 5% nor are the heat values adjusted for ULSD oil content.

Attachment 1 presents in graphical and tabular form the mass consumption data derived from Reference 5 for all three EDGs.

At 1750 kW, the mass consumption rate of EDG 32 is 901.3 lb / hr. Rounding this result upward to the nearest whole number yields 902 lb / hr.

- Fuel oil mass used in 48 hrs:

48 hrs x 902 lb / hr = 43,296 lb

- Total energy contained in this mass of SG 0.83 fuel oil:

43,296 lb x 18,484.7 Btu / lb = 800,313,571.2 Btu

- Gallons of SG 0.83 fuel oil needed to provide this amount of energy:

800,313,571.2 Btu ÷ 127,906.2 Btu / gal = 6,257.0 gallons

10.3 Conservative Determination of Fuel Oil Usage in 48 Hours of EDG Operation [Maximum Loading Profile Run with Testing and ULSD Heat Value Conservatisms Included]

EDG run times for the 48 hour period at the specified loadings are the following:

1 hour at 2000 kW
4 hours at 1950 kW
43 hours at 1750 kW

The above profile is based on the previously defined EDG 24 hour maximum loading profile being repeated twice. From a fuel oil consumption perspective this is conservative since in reality for any accident scenario with Loss-of-Offsite-Power (LOOP), EDG loading would not exceed 1750 kW after the first 24 hours of the event [Ref 8].

As stated in Section 10.2, according to ALCO test data EDG 32 (Serial Number 9735) consumes the greatest amount of fuel oil mass relative to a specific loading value. Therefore, it is conservative to use EDG 32 consumption data for this calculation.

To account for any uncertainty in fuel oil consumption rate during initial EDG testing, in this conservative calculation the 2000 kW, 1950 kW, and 1750 kW mass consumption rates for EDG 32 are increased by 5% from the values in the Attachment 1 table.

At a load of 2000 kW, the extrapolated test data show a fuel oil mass consumption rate of 1019.2 lb / hr. At 1950 kW, the data show a mass consumption rate of 995.6 lb / hr. At

1750 kW, the mass consumption rate is 901.3 lb / hr. Increasing each of these values by 5%, and rounding the result to the nearest whole number, yields the following:

2000 kW: 1070 lb / hr
1950 kW: 1045 lb / hr
1750 kW: 946 lb / hr

- Fuel oil mass used in 48 hrs:

1 hr x 1070 lb / hr = 1,070 lb
4 hrs x 1045 lb / hr = 4,180 lb
43 hrs x 946 lb / hr = 40,678 lb

Total Mass = 45,928 lb

- Total energy contained in this mass of SG 0.83 fuel oil:

45,928 lb x 18,762.0 Btu / lb = 861,701,136 Btu

- Gallons of SG 0.83 fuel oil needed to provide this amount of energy:

861,701,136 Btu ÷ 125,987.6 Btu / gal = 6,839.6 gallons or ~6,840 gallons

48 hour volumetric usages of fuel oil for the other specific gravities and heat values cited in Table 10.1 – 2 can be obtained by utilizing the same approach as above. The total mass of fuel oil consumed in 48 hours would be maintained constant since that is directly dependent on the ALCO test data and EDG load profile while the heat values would vary with the corresponding specific gravity. The analytical work and results are shown in Table 10.3 – 1 below.

Table 10.3 – 1 Fuel Oil Consumptions for 48 Hour EDG Operation of ULSD Fuel Oils of Varying Specific Gravity

Specific Gravity	Calculation	Result (gallons)
0.8348	[45,928 x 18,736.9] / 126,572.5 =	6798.9
0.8448	[45,928 x 18,686.2] / 127,754.5 =	6717.7
0.8550	[45,928 x 18,635.4] / 128,936.5 =	6638.0
0.8654	[45,928 x 18,584.7] / 130,118.5 =	6559.9
0.8762	[45,928 x 18,523.8] / 131,300.5 =	6479.5
0.8871	[45,928 x 18,462.9] / 132,581.0 =	6395.8
0.8900	[45,928 x 18,447.2] / 132,884.4 =	6375.8

10.4 Method 1 Determination of Fuel Oil Usage of One and Two EDGs Operating for 7 Days [100% Rated Capacity Run with Testing and ULSD Heat Value Conservatisms NOT Included]

- Fuel oil mass used in 168 hrs (7 days):

168 hrs x 902 lb / hr = 151,536 lb

- Total energy contained in this mass of SG 0.83 fuel oil:

151,536 lb x 18,484.7 Btu / lb = 2,801,097,499 Btu

- Gallons of SG 0.83 fuel oil needed to provide this amount of energy:

2,801,097,499 Btu ÷ 127,906.2 Btu / gal = 21,899.6 gallons or ~21,900 gallons

Since the current and future licensing basis requirement in Reference 3 is that two EDGs are available to supply power for the 7 day operating duration; the above fuel oil volume result must be doubled.

- Gallons of SG 0.83 fuel oil necessary to operate two EDGs for 7 days at the 100% rated capacity:

21,900 gallons x 2 = 43,800 gallons

10.5 Conservative Determination of Fuel Oil Usage of One and Two EDGs Operating for 7 Days [Maximum Loading Profile Run with Testing and ULSD Heat Value Conservatisms Included]

EDG run times for the 7 day (168 hours) period at the specified loadings are the following:

3.5 hours at 2000 kW
14 hours at 1950 kW
150.5 hours at 1750 kW

The previously defined EDG 24 hour maximum loading profile is conservatively repeated seven times in determining the fuel oil consumption in 7 days. The same fuel oil consumption rates for each EDG load value that were used in Section 10.3, with the 5% margin increase included, are applied in this calculation.

- Fuel oil mass used in 168 hrs (7 days):

3.5 hrs x 1070 lb / hr = 3,745 lb
14 hrs x 1045 lb / hr = 14,630 lb
150.5 hrs x 946 lb / hr = 142,373 lb

Total Mass = 160,748 lb

- Total energy contained in this mass of SG 0.83 fuel oil:

160,748 lb x 18,762.0 Btu / lb = 3,015,953,976 Btu

- Gallons of SG 0.83 fuel oil needed to provide this amount of energy:

3,015,953,976 Btu ÷ 125,987.6 Btu / gal = 23,938.5 gallons or ~23,939 gallons

Since the current and future licensing basis requirement in Reference 3 is that two EDGs are available to supply power for the 7 day operating duration; the above fuel oil volume result must be doubled.

- Gallons of SG 0.83 fuel oil necessary to operate two EDGs for 7 days at the stated maximum loading profile:

23,939 gallons x 2 = 47,878 gallons

7 day volumetric usages of fuel oil for the other specific gravities and heat values cited in Table 10.1 – 2 can be obtained by utilizing the same approach as above. The total mass consumed in 7 days would be maintained constant since that is directly dependent on the ALCO test data and EDG load profile while the heat values would vary with the corresponding specific gravity. The analytical work and results are shown in Table 10.5 – 1 below.

Table 10.5 – 1 Fuel Oil Consumptions for 7 Day EDG Operation of ULSD Fuel Oils of Varying Specific Gravity

Specific Gravity	Calculation	Single EDG Result (gal)	Two EDG Result (gal)
0.8348	[160,748 x 18,736.9] / 126,572.5 =	23,796.0	47,592.0
0.8448	[160,748 x 18,686.2] / 127,754.5 =	23,512.0	47,024.1
0.8550	[160,748 x 18,635.4] / 128,936.5 =	23,233.2	46,466.3
0.8654	[160,748 x 18,584.7] / 130,118.5 =	22,959.5	45,919.0
0.8762	[160,748 x 18,523.8] / 131,300.5 =	22,678.2	45,356.5
0.8871	[160,748 x 18,462.9] / 132,581.0 =	22,385.4	44,770.7
0.8900	[160,748 x 18,447.2] / 132,884.4 =	22,315.3	44,630.5

10.6 Conservative Determination of Fuel Oil Usage of One and Two EDGs Operating for 6 Days [Maximum Loading Profile Run with Testing and ULSD Heat Value Conservatisms Included]

A six day operating case is performed in addition to the 7 day case in order to provide a fuel oil usage value supporting a proposed Technical Specification change concerning a "Required Action" (AOT / LCO). If in the future, during Technical Specification - mandated surveillance the total volume of fuel oil is discovered to be less than the 7 day stipulation but equal to or greater than the 6 day amount, the volume must be restored to the 7 day required value within a specified time period (eg., 48 hours). This is defined as the Required Action and associated Time to implement the Action.

{Discussion of why both a 7 and 6 day fuel oil usage value is necessary to be calculated is contained in Improved Standard Technical Specification Task Force Change Traveler TSTF-501-A, Rev 1 [Ref 15].}

EDG run times for the 6 day (144 hours) period at the specified loadings are the following:

3 hours at 2000 kW
12 hours at 1950 kW
129 hours at 1750 kW

The previously defined EDG 24 hour maximum loading profile is in this case repeated six times to determine the fuel oil consumption in 6 days. The same fuel oil consumption rates for each EDG load value that were used in Section 10.3, with the 5% margin increase included, are applied in this calculation.

- Fuel oil mass used in 144 hrs (6 days):

3.0 hrs x 1070 lb / hr = 3,210 lb
12 hrs x 1045 lb / hr = 12,540 lb
129 hrs x 946 lb / hr = 122,034 lb

Total Mass = 137,784 lb

- Total energy contained in this mass of SG 0.83 fuel oil:

137,784 lb x 18,762.0 Btu / lb = 2,585,103,408 Btu

- Gallons of SG 0.83 fuel oil needed to provide this amount of energy:

2,585,103,408 Btu ÷ 125,987.6 Btu / gal = 20,518.7 gallons or ~20,519 gallons

Since for the 6 day operating duration two EDGs are supplying power at the stated maximum loading profile, the above fuel oil volume result must be doubled.

20,519 gallons x 2 = 41,038 gallons

6 day volumetric usages of fuel oil for the other specific gravities and heat values cited in Table 10.1 – 2 are also obtained. The analytical work and results are shown in Table 10.6 – 1 below.

Table 10.6 – 1 Fuel Oil Consumptions for 6 Day EDG Operation of ULSD Fuel Oils of Varying Specific Gravity

Specific Gravity	Calculation	Single EDG Result (gal)	Two EDG Result (gal)
0.8348	[137,784 x 18,736.9] / 126,572.5 =	20,396.6	40,793.1
0.8448	[137,784 x 18,686.2] / 127,754.5 =	20,153.2	40,306.4
0.8550	[137,784 x 18,635.4] / 128,936.5 =	19,914.1	39,828.3
0.8654	[137,784 x 18,584.7] / 130,118.5 =	19,679.6	39,359.1
0.8762	[137,784 x 18,523.8] / 131,300.5 =	19,438.5	38,877.0
0.8871	[137,784 x 18,462.9] / 132,581.0 =	19,187.5	38,374.9
0.8900	[137,784 x 18,447.2] / 132,884.4 =	19,127.4	38,254.8

10.7 Method 1 Determination of Fuel Oil Usage of Three EDGs Operating for 7 Days [100% Rated Capacity Run with Testing and ULSD Heat Value Conservatisms NOT Included]

If during an accident / LOOP scenario there is no failure of an EDG to start and load, all three EDGs would then run and consume fuel oil. In the Method 1 approach, the third EDG operates at 100% rated capacity for the entire 7 day period in calculating total fuel oil usage.

It was determined in Section 10.4 that each EDG operating at 100% rated capacity would consume 21,900 gallons of SG 0.83 fuel oil in the 7 day period.

Therefore, total 7-day consumption of SG 0.83 fuel oil for three EDGs would be:

21,900 gallons x 3 = 65,700 gallons

10.8 Conservative Determination of Fuel Oil Usage of Three EDGs Operating for 7 Days [Maximum Loading Profile Run with Testing and ULSD Heat Value Conservatisms Included]

The same as in Section 10.7 above, if one EDG doesn't fail all three EDGs would then run and consume fuel oil. It is conservative to assume that the third EDG operates at maximum loading profile for the entire 7 day period in calculating total fuel oil usage.

EDG run times for the 7 day (168 hours) period at the specified loadings are as defined in Section 10.5. It was determined in that Section that each EDG operating at maximum load profile would consume 23,939 gallons of SG 0.83 fuel oil in the 7 day period.

Therefore, total 7-day consumption of SG 0.83 fuel oil for three EDGs would be:

23,939 gallons x 3 = 71,817 gallons

The 7 day volumetric consumptions of fuel oils of the other specific gravities and heat values stated in Table 10.1- 2 can be determined by simply multiplying by three the "Single EDG Results" of Table 10.5 - 1. The analytical work and results of this exercise are shown in Table 10.8 – 1 below.

Table 10.8 – 1 Fuel Oil Consumptions for 7 Day Three EDG Operation of ULSD Fuel Oils of Varying Specific Gravity

Specific Gravity	Calculation	Three EDG Result (gal)
0.8348	23,796.0 x 3 =	71,388.0
0.8448	23,512.0 x 3 =	70,536.0
0.8550	23,233.2 x 3 =	69,699.6
0.8654	22,959.5 x 3 =	68,878.5
0.8762	22,678.2 x 3 =	68,034.6
0.8871	22,385.4 x 3 =	67,156.2
0.8900	22,315.3 x 3 =	66,945.9

10.9 Conservative Determination of Fuel Oil Usage of Three EDGs Operating for 6 Days [Maximum Loading Profile Run with Testing and ULSD Heat Value Conservatisms Included]

For the reason provided in Section 10.6, there is a need to determine the fuel oil consumption in a 6 day operating period. If three rather than two EDGs start and operate at maximum load profile throughout the entire 6 day timeframe, a different fuel oil usage will occur than the 41,038 gallons of SG 0.83 fuel oil previously calculated.

EDG run times for the 6 day (144 hours) period at the specified loadings are as stated in Section 10.6. It was determined in that Section that each EDG would consume a maximum of 20,519 gallons of SG 0.83 fuel oil during the 6 day period.

Therefore, total 6-day consumption of SG 0.83 fuel oil for three EDGs would be:

20,519 gallons x 3 = 61,557 gallons

The 6 day volumetric consumptions of fuel oils of the other specific gravities and heat values stated in Table 10.1-2 can be determined by simply multiplying the "Single EDG

Results" of Table 10.6 - 1 by three. The analytical work and results of this exercise are shown in Table 10.9 – 1 below.

Table 10.9 – 1 Fuel Oil Consumptions for 6 Day Three EDG Operation of ULSD Fuel Oils of Varying Specific Gravity

Specific Gravity	Calculation	Three EDG Result (gal)
0.8348	20,396.6 x 3 =	61,189.8
0.8448	20,153.2 x 3 =	60,459.6
0.8550	19,914.1 x 3 =	59,742.3
0.8654	19,679.6 x 3 =	59,038.8
0.8762	19,438.5 x 3 =	58,315.5
0.8871	19,187.5 x 3 =	57,562.5
0.8900	19,127.4 x 3 =	57,382.2

10.10 Determination of Maximum Fuel Oil Consumption Rate at a Load of 1750 kW

To determine the total number of hours that a Fuel Oil Storage Tank can supply its corresponding EDG operating at maximum load profile with worst-case fuel oil, the maximum volumetric fuel oil consumption rate of the EDG at a load of 1750 kW must first be calculated.

Maximum Volumetric Consumption Rate $_{(at\ 1750\ kW)}$ =
(Mass Consumption Rate at 1750 kW x Fuel Oil Mass Heat Value) / (Fuel Oil Volumetric Heat Value)

Maximum Volumetric Consumption Rate $_{(at\ 1750\ kW)}$ =
(946 lb/hr x 18,762.0 Btu/lb) / (125,987.6 Btu/gal)

Maximum Volumetric Consumption Rate $_{(at\ 1750\ kW)}$ = (17,748,852 Btu/hr) / (125,987.6 Btu/gal)

Maximum Volumetric Consumption Rate $_{(at\ 1750\ kW)}$ = 140.88 gal/hr, or 141 gallons / hour

The nominal storage capacity of an individual EDG Fuel Oil Storage Tank is approximately 7700 gallons (Ref 14). Of this capacity, however, a significant portion is considered to be "unusable" volume due to factors such as Fuel Oil Transfer Pump submergence requirements, tank orientation (ie, slope), inner tank coating, and level instrument uncertainty. The sum total of the fuel oil consumed by an EDG and the "unusable" volume in the associated FOST must equal or be less than 7700 gallons. Based on fuel oil amounts cited in the table in UFSAR section 8.2.3, the maximum "unusable" volume in any FOST is 1031 gallons. Subtracting this quantity from the nominal tank capacity leaves 6669 gallons at most available for EDG consumption.

It was determined in section 10.3 of this calculation that an EDG operating at its maximum loading profile for 48 hours could conservatively consume as much as 6,840 gallons of SG 0.83 fuel oil. Since only a maximum of 6669 gallons of the fuel oil in an FOST is considered "usable", the EDG cannot be run at the greatest loading profile for 48 hours with worst-case fuel oil without refill of the tank.

To obtain the EDG consumption in 48 hours, the 24 hour maximum load profile was repeated twice. However, to determine fuel oil consumption of an EDG for an operating period less than 48 hours, this simplified approach cannot be applied. From section 10.3 information, it is clear that EDG fuel oil consumption depends on EDG load, with higher consumption correlating to higher load and vice versa. Therefore, to be conservative in calculating overall consumption for a timeframe shorter than 48 hours, the time of EDG operation at 1750 kW will be decreased from the present 43 hours. This is conservative because reducing run time only at the lowest consumption rate of the EDG maximum load profile results in the smallest reduction in total fuel oil usage within a defined time period.

From the paragraph above it is known that at least 171 gallons (6,840 – 6,669 gallons = 171 gallons) of additional "usable" worst case fuel oil is necessary in its associated FOST to permit an EDG to operate for 48 hours at maximum load profile. Since this fuel oil amount is deemed not to be available in the FOST, the EDG can only operate for less than the 48 hour duration. In this specific case, the operating time decrease is about 1.2 hours, for a total of 46.8 hours of operation [48 hrs – (171 gal / 141 gal/hr]) = 46.8 hrs]. The maximum volumetric consumption rate of 141 gallons / hour can be used similarly as above to determine any EDG operating time less than 48 hours depending on the "usable" volume of limiting fuel oil desired to be maintained in the FOST.

In Section 10.2 of this calculation, it was determined that an EDG operating at 100% rated capacity would consume 6,257 gallons of SG 0.83 fuel oil in 48 hours. Subtracting this volume from the FOST nominal capacity of 7700 gallons leaves 1443 gallons, which is significantly greater than the maximum 1031 gallons "unusable" volume previously mentioned. Therefore, it can be concluded that under the Regulatory Guide 1.137 requirement of EDG operation at rated capacity (1750 kW), with no conservative assumptions made as to ALCO test data uncertainty or fuel oil heat values, a FOST would contain sufficient "usable" fuel oil to allow its associated EDG to run for 48 hours.

11.0 References

1. IP3-CALC-EG-00217 Rev 4, "Emergency Diesel Generator Storage Tank Level Setpoints"
2. CR-IP3-2010-03088, "IP3 2010 NRC CDBI Questions on EDG Fuel Oil Usage Section of IP3-CALC-EG-00217"
3. IP3 Technical Specification Basis 3.8.3, "Diesel Fuel Oil and Starting Air"
4. IP3 Technical Specification Basis 3.8.1, "AC Sources – Operating"

5. Duke Prod 9321-01-102-1, "Emergency Back-up Diesel Generators – Vendor Surveillance Report and Test Documentation" (See Attachment 2)
6. Procedure 0-CY-1810 Rev 11, "Diesel Fuel Oil Monitoring"
7. IP-RPT-11-00050 Rev 0 (Report MPR-2980 Rev 0), "Evaluation of Ultra Low Sulfur Diesel Fuel Oil for Use in EDGs", dated December 4, 2006 (See Attachment 3)
8. IP3-CALC-ED-00207 Rev 8, "480V Buses 2A, 3A, 5A & 6A, and EDGs 31, 32 and 33 Accident Loading"
9. Telephone Conversation (6/2/2011) with Mark O'Connell of MPR Associates; RE: Discussion of diesel fuel oil heat values cited in Table 4-2 of MPR Associates Report MPR-2980 Rev 0. (See Attachment 3)
10. Telephone Conversation (9/12/2011) with James Peters of the IPEC Chemistry Department; RE: Application of Ultra Low Sulfur Diesel (ULSD) fuel oil standard to fuel oil delivered for use in IPEC EDGs (See Attachment 4)
11. IP-CALC-11-00011 Rev 0, "Evaluation of Emergency Diesel Generator (EDG) Fuel Oil Usages Accounting for Issues Identified During the IP3 2010 NRC CDBI"
12. CR-IP3-2011-03960, "Technical Specification 3.8.3 for EDG Usable Fuel Oil Volumes Found to be Non-Conservative Based on Results of Calculation IP-CALC-11-00011 Rev 0"
13. IP3 Technical Specification 5.5.12, "Diesel Fuel Oil Testing Program"
14. Drawing IP3V-0353-0002 Rev 2, "Fuel Oil Storage Tank (7700 Gallons)"
15. Improved Standard Technical Specification Task Force Change Traveler TSTF-501-A, Rev 1, "Relocate Stored Fuel Oil and Lube Oil Volume Values to Licensee Control"

12.0 Attachments

Attachment 1 – Mass Fuel Oil Consumption versus EDG Load (9 Pages)

Attachment 2 – EDG 31, 32, 33 Original Test Data from WEDCO Purchase Order 9321-01-102-1 (16 pages)

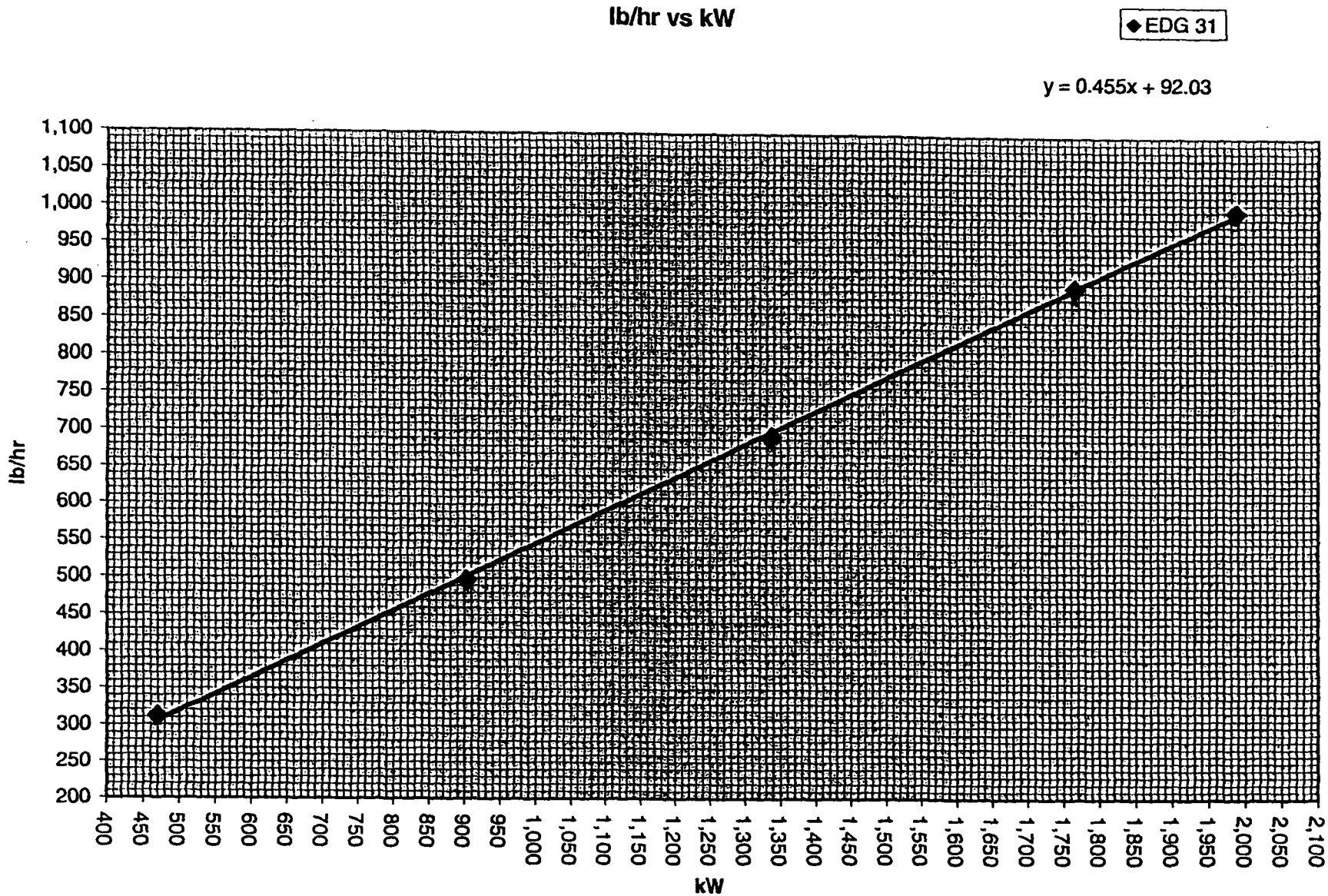
Attachment 3 – Excerpt from Reference 6: Table 4-2. High and Low Heat Value of Some Typical Diesel Fuels; Telecon of Discussion with MPR Associates on Diesel Fuel Oil Heat Values (3 pages)

Attachment 4 – Documentation of 9/12/2011 Telephone Conversation with James Peters (IPEC Chemistry Department); RE: Application of Ultra Low Sulfur Diesel (ULSD) fuel oil standard to fuel oil delivered for use in IPEC EDGs (2 pages)

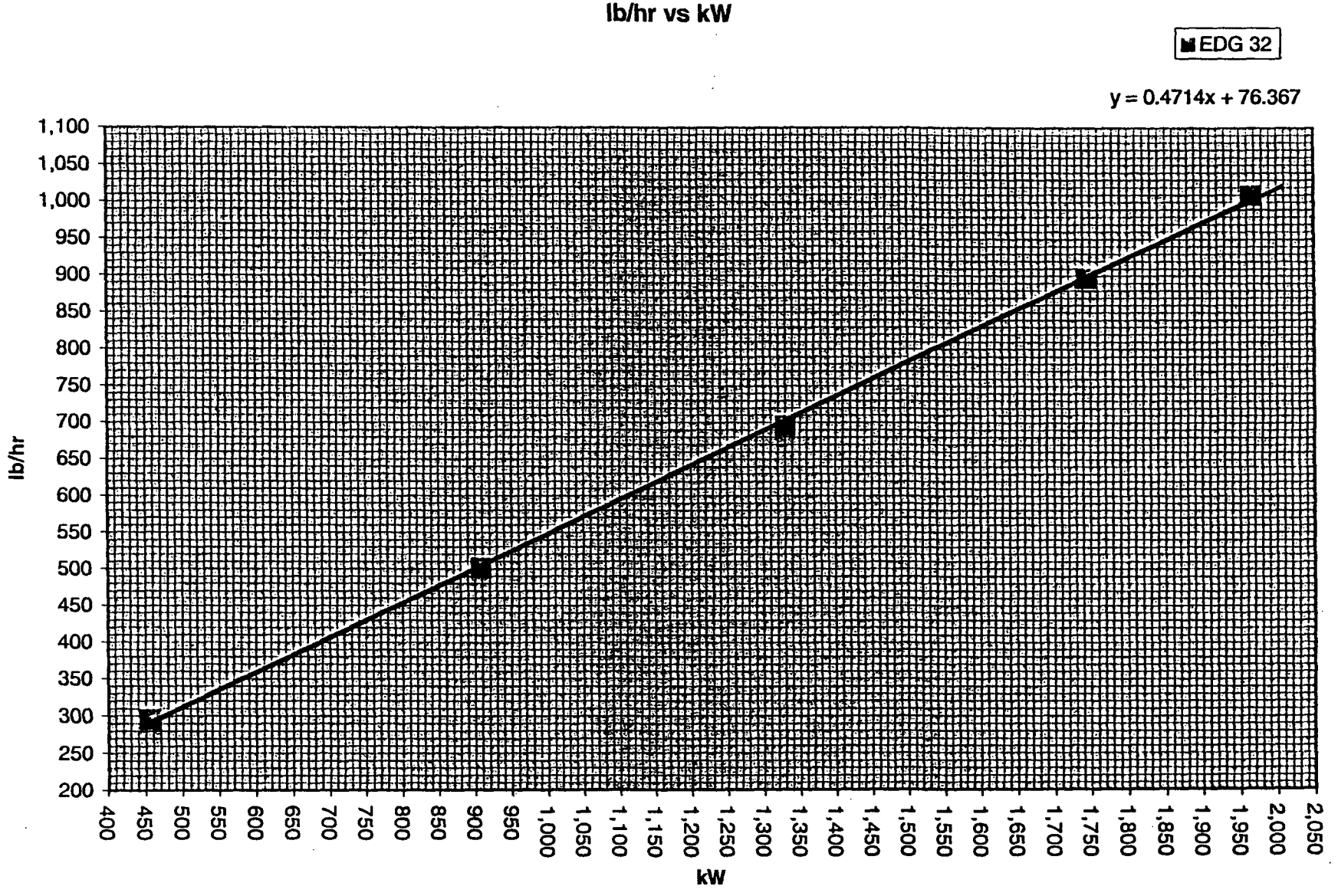
ATTACHMENT 1

Mass Fuel Oil Consumption
Vs
EDG Load

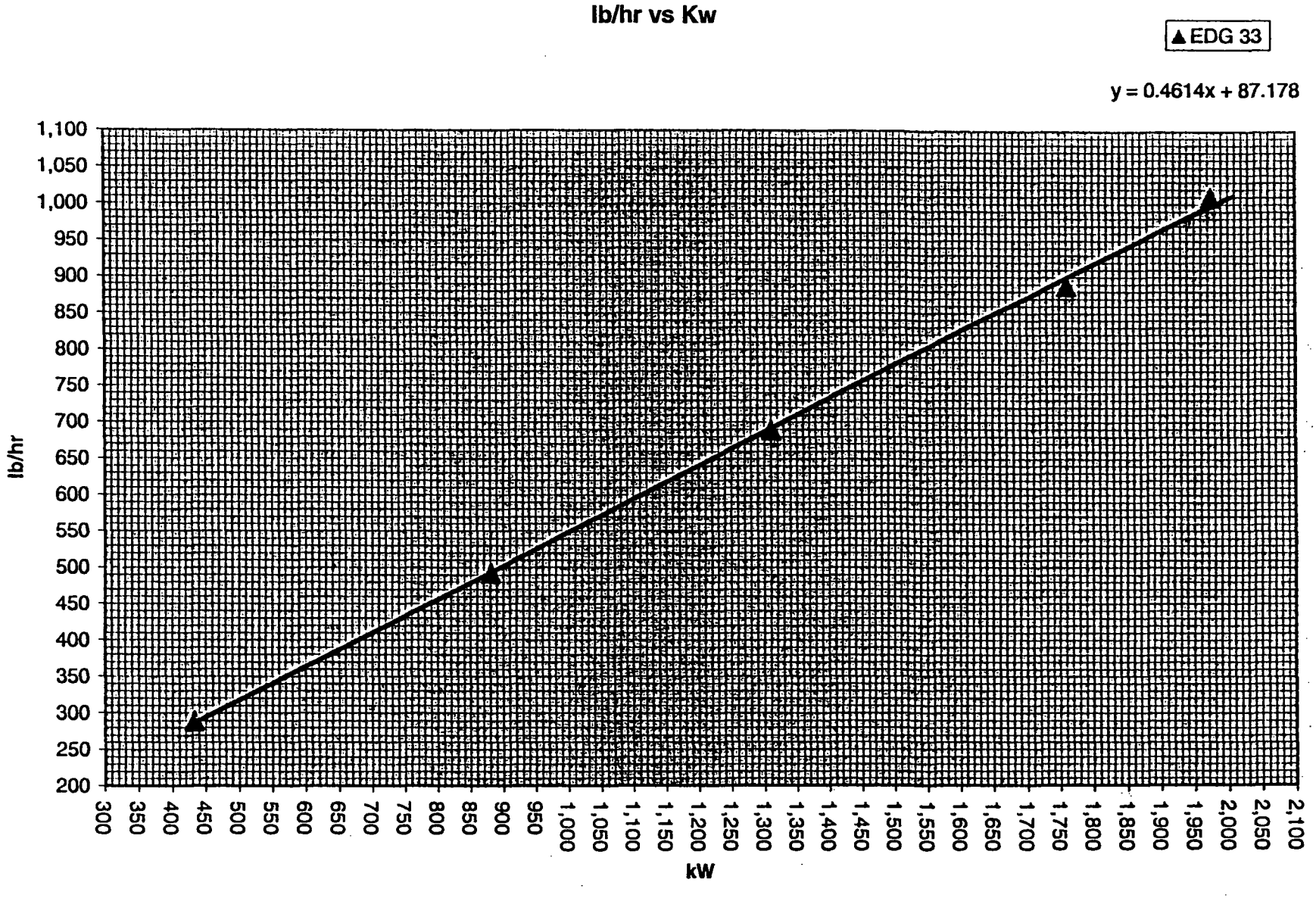
Attachment 1



Attachment 1



Attachment 1



Attachment 1

EDG 31		EDG 32		EDG 33	
KW	lb/hr	KW	lb/hr	KW	lb/hr
0.0	92.0	0.0	76.4	0.0	87.2
10.0	96.6	10.0	81.1	10.0	91.8
20.0	101.1	20.0	85.8	20.0	96.4
30.0	105.7	30.0	90.5	30.0	101.0
40.0	110.2	40.0	95.2	40.0	105.6
50.0	114.8	50.0	99.9	50.0	110.2
60.0	119.3	60.0	104.7	60.0	114.9
70.0	123.9	70.0	109.4	70.0	119.5
80.0	128.4	80.0	114.1	80.0	124.1
90.0	133.0	90.0	118.8	90.0	128.7
100.0	137.5	100.0	123.5	100.0	133.3
110.0	142.1	110.0	128.2	110.0	137.9
120.0	146.6	120.0	132.9	120.0	142.5
130.0	151.2	130.0	137.6	130.0	147.2
140.0	155.7	140.0	142.4	140.0	151.8
150.0	160.3	150.0	147.1	150.0	156.4
160.0	164.8	160.0	151.8	160.0	161.0
170.0	169.4	170.0	156.5	170.0	165.6
180.0	173.9	180.0	161.2	180.0	170.2
190.0	178.5	190.0	165.9	190.0	174.8
200.0	183.0	200.0	170.6	200.0	179.5
210.0	187.6	210.0	175.4	210.0	184.1
220.0	192.1	220.0	180.1	220.0	188.7
230.0	196.7	230.0	184.8	230.0	193.3
240.0	201.2	240.0	189.5	240.0	197.9
250.0	205.8	250.0	194.2	250.0	202.5
260.0	210.3	260.0	198.9	260.0	207.1
270.0	214.9	270.0	203.6	270.0	211.8
280.0	219.4	280.0	208.4	280.0	216.4
290.0	224.0	290.0	213.1	290.0	221.0
300.0	228.5	300.0	217.8	300.0	225.6
310.0	233.1	310.0	222.5	310.0	230.2
320.0	237.6	320.0	227.2	320.0	234.8
330.0	242.2	330.0	231.9	330.0	239.4
340.0	246.7	340.0	236.6	340.0	244.1
350.0	251.3	350.0	241.4	350.0	248.7
360.0	255.8	360.0	246.1	360.0	253.3
370.0	260.4	370.0	250.8	370.0	257.9
380.0	264.9	380.0	255.5	380.0	262.5

Attachment 1

EDG 31		EDG 32		EDG 33	
kw	lb/hr	kw	lb/hr	kw	lb/hr
390.0	269.5	390.0	260.2	390.0	267.1
400.0	274.0	400.0	264.9	400.0	271.7
410.0	278.6	410.0	269.6	410.0	276.4
420.0	283.1	420.0	274.4	420.0	281.0
430.0	287.7	430.0	279.1	430.0	285.6
440.0	292.2	440.0	283.8	440.0	290.2
450.0	296.8	450.0	288.5	450.0	294.8
460.0	301.3	460.0	293.2	460.0	299.4
470.0	305.9	470.0	297.9	470.0	304.0
480.0	310.4	480.0	302.6	480.0	308.7
490.0	315.0	490.0	307.4	490.0	313.3
500.0	319.5	500.0	312.1	500.0	317.9
510.0	324.1	510.0	316.8	510.0	322.5
520.0	328.6	520.0	321.5	520.0	327.1
530.0	333.2	530.0	326.2	530.0	331.7
540.0	337.7	540.0	330.9	540.0	336.3
550.0	342.3	550.0	335.6	550.0	340.9
560.0	346.8	560.0	340.4	560.0	345.6
570.0	351.4	570.0	345.1	570.0	350.2
580.0	355.9	580.0	349.8	580.0	354.8
590.0	360.5	590.0	354.5	590.0	359.4
600.0	365.0	600.0	359.2	600.0	364.0
610.0	369.6	610.0	363.9	610.0	368.6
620.0	374.1	620.0	368.6	620.0	373.2
630.0	378.7	630.0	373.3	630.0	377.9
640.0	383.2	640.0	378.1	640.0	382.5
650.0	387.8	650.0	382.8	650.0	387.1
660.0	392.3	660.0	387.5	660.0	391.7
670.0	396.9	670.0	392.2	670.0	396.3
680.0	401.4	680.0	396.9	680.0	400.9
690.0	406.0	690.0	401.6	690.0	405.5
700.0	410.5	700.0	406.3	700.0	410.2
710.0	415.1	710.0	411.1	710.0	414.8
720.0	419.6	720.0	415.8	720.0	419.4
730.0	424.2	730.0	420.5	730.0	424.0
740.0	428.7	740.0	425.2	740.0	428.6
750.0	433.3	750.0	429.9	750.0	433.2
760.0	437.8	760.0	434.6	760.0	437.8
770.0	442.4	770.0	439.3	770.0	442.5
780.0	446.9	780.0	444.1	780.0	447.1
790.0	451.5	790.0	448.8	790.0	451.7
800.0	456.0	800.0	453.5	800.0	456.3

Attachment 1

EDG 31		EDG 32		EDG 33	
kW	lb/hr	kW	lb/hr	kW	lb/hr
810.0	460.6	810.0	458.2	810.0	460.9
820.0	465.1	820.0	462.9	820.0	465.5
830.0	469.7	830.0	467.6	830.0	470.1
840.0	474.2	840.0	472.3	840.0	474.8
850.0	478.8	850.0	477.1	850.0	479.4
860.0	483.3	860.0	481.8	860.0	484.0
870.0	487.9	870.0	486.5	870.0	488.6
880.0	492.4	880.0	491.2	880.0	493.2
890.0	497.0	890.0	495.9	890.0	497.8
900.0	501.5	900.0	500.6	900.0	502.4
910.0	506.1	910.0	505.3	910.0	507.1
920.0	510.6	920.0	510.1	920.0	511.7
930.0	515.2	930.0	514.8	930.0	516.3
940.0	519.7	940.0	519.5	940.0	520.9
950.0	524.3	950.0	524.2	950.0	525.5
960.0	528.8	960.0	528.9	960.0	530.1
970.0	533.4	970.0	533.6	970.0	534.7
980.0	537.9	980.0	538.3	980.0	539.4
990.0	542.5	990.0	543.1	990.0	544.0
1,000.0	547.0	1,000.0	547.8	1,000.0	548.6
1,010.0	551.6	1,010.0	552.5	1,010.0	553.2
1,020.0	556.1	1,020.0	557.2	1,020.0	557.8
1,030.0	560.7	1,030.0	561.9	1,030.0	562.4
1,040.0	565.2	1,040.0	566.6	1,040.0	567.0
1,050.0	569.8	1,050.0	571.3	1,050.0	571.6
1,060.0	574.3	1,060.0	576.1	1,060.0	576.3
1,070.0	578.9	1,070.0	580.8	1,070.0	580.9
1,080.0	583.4	1,080.0	585.5	1,080.0	585.5
1,090.0	588.0	1,090.0	590.2	1,090.0	590.1
1,100.0	592.5	1,100.0	594.9	1,100.0	594.7
1,110.0	597.1	1,110.0	599.6	1,110.0	599.3
1,120.0	601.6	1,120.0	604.3	1,120.0	603.9
1,130.0	606.2	1,130.0	609.0	1,130.0	608.6
1,140.0	610.7	1,140.0	613.8	1,140.0	613.2
1,150.0	615.3	1,150.0	618.5	1,150.0	617.8
1,160.0	619.8	1,160.0	623.2	1,160.0	622.4
1,170.0	624.4	1,170.0	627.9	1,170.0	627.0
1,180.0	628.9	1,180.0	632.6	1,180.0	631.6
1,190.0	633.5	1,190.0	637.3	1,190.0	636.2
1,200.0	638.0	1,200.0	642.0	1,200.0	640.9
1,210.0	642.6	1,210.0	646.8	1,210.0	645.5
1,220.0	647.1	1,220.0	651.5	1,220.0	650.1

Attachment 1

EDG 31		EDG 32		EDG 33	
kW	lb/hr	kW	lb/hr	kW	lb/hr
1,230.0	651.7	1,230.0	656.2	1,230.0	654.7
1,240.0	656.2	1,240.0	660.9	1,240.0	659.3
1,250.0	660.8	1,250.0	665.6	1,250.0	663.9
1,260.0	665.3	1,260.0	670.3	1,260.0	668.5
1,270.0	669.9	1,270.0	675.0	1,270.0	673.2
1,280.0	674.4	1,280.0	679.8	1,280.0	677.8
1,290.0	679.0	1,290.0	684.5	1,290.0	682.4
1,300.0	683.5	1,300.0	689.2	1,300.0	687.0
1,310.0	688.1	1,310.0	693.9	1,310.0	691.6
1,320.0	692.6	1,320.0	698.6	1,320.0	696.2
1,330.0	697.2	1,330.0	703.3	1,330.0	700.8
1,340.0	701.7	1,340.0	708.0	1,340.0	705.5
1,350.0	706.3	1,350.0	712.8	1,350.0	710.1
1,360.0	710.8	1,360.0	717.5	1,360.0	714.7
1,370.0	715.4	1,370.0	722.2	1,370.0	719.3
1,380.0	719.9	1,380.0	726.9	1,380.0	723.9
1,390.0	724.5	1,390.0	731.6	1,390.0	728.5
1,400.0	729.0	1,400.0	736.3	1,400.0	733.1
1,410.0	733.6	1,410.0	741.0	1,410.0	737.8
1,420.0	738.1	1,420.0	745.8	1,420.0	742.4
1,430.0	742.7	1,430.0	750.5	1,430.0	747.0
1,440.0	747.2	1,440.0	755.2	1,440.0	751.6
1,450.0	751.8	1,450.0	759.9	1,450.0	756.2
1,460.0	756.3	1,460.0	764.6	1,460.0	760.8
1,470.0	760.9	1,470.0	769.3	1,470.0	765.4
1,480.0	765.4	1,480.0	774.0	1,480.0	770.1
1,490.0	770.0	1,490.0	778.8	1,490.0	774.7
1,500.0	774.5	1,500.0	783.5	1,500.0	779.3
1,510.0	779.1	1,510.0	788.2	1,510.0	783.9
1,520.0	783.6	1,520.0	792.9	1,520.0	788.5
1,530.0	788.2	1,530.0	797.6	1,530.0	793.1
1,540.0	792.7	1,540.0	802.3	1,540.0	797.7
1,550.0	797.3	1,550.0	807.0	1,550.0	802.3
1,560.0	801.8	1,560.0	811.8	1,560.0	807.0
1,570.0	806.4	1,570.0	816.5	1,570.0	811.6
1,580.0	810.9	1,580.0	821.2	1,580.0	816.2
1,590.0	815.5	1,590.0	825.9	1,590.0	820.8
1,600.0	820.0	1,600.0	830.6	1,600.0	825.4
1,610.0	824.6	1,610.0	835.3	1,610.0	830.0
1,620.0	829.1	1,620.0	840.0	1,620.0	834.6
1,630.0	833.7	1,630.0	844.7	1,630.0	839.3
1,640.0	838.2	1,640.0	849.5	1,640.0	843.9

Attachment 1

EDG 31		EDG 32		EDG 33	
kW	lb/hr	kW	lb/hr	kW	lb/hr
1,650.0	842.8	1,650.0	854.2	1,650.0	848.5
1,660.0	847.3	1,660.0	858.9	1,660.0	853.1
1,670.0	851.9	1,670.0	863.6	1,670.0	857.7
1,680.0	856.4	1,680.0	868.3	1,680.0	862.3
1,690.0	861.0	1,690.0	873.0	1,690.0	866.9
1,700.0	865.5	1,700.0	877.7	1,700.0	871.6
1,710.0	870.1	1,710.0	882.5	1,710.0	876.2
1,720.0	874.6	1,720.0	887.2	1,720.0	880.8
1,730.0	879.2	1,730.0	891.9	1,730.0	885.4
1,740.0	883.7	1,740.0	896.6	1,740.0	890.0
1,750.0	888.3	1,750.0	901.3	1,750.0	894.6
1,760.0	892.8	1,760.0	906.0	1,760.0	899.2
1,770.0	897.4	1,770.0	910.7	1,770.0	903.9
1,780.0	901.9	1,780.0	915.5	1,780.0	908.5
1,790.0	906.5	1,790.0	920.2	1,790.0	913.1
1,800.0	911.0	1,800.0	924.9	1,800.0	917.7
1,810.0	915.6	1,810.0	929.6	1,810.0	922.3
1,820.0	920.1	1,820.0	934.3	1,820.0	926.9
1,830.0	924.7	1,830.0	939.0	1,830.0	931.5
1,840.0	929.2	1,840.0	943.7	1,840.0	936.2
1,850.0	933.8	1,850.0	948.5	1,850.0	940.8
1,860.0	938.3	1,860.0	953.2	1,860.0	945.4
1,870.0	942.9	1,870.0	957.9	1,870.0	950.0
1,880.0	947.4	1,880.0	962.6	1,880.0	954.6
1,890.0	952.0	1,890.0	967.3	1,890.0	959.2
1,900.0	956.5	1,900.0	972.0	1,900.0	963.8
1,910.0	961.1	1,910.0	976.7	1,910.0	968.5
1,920.0	965.6	1,920.0	981.5	1,920.0	973.1
1,930.0	970.2	1,930.0	986.2	1,930.0	977.7
1,940.0	974.7	1,940.0	990.9	1,940.0	982.3
1,950.0	979.3	1,950.0	995.6	1,950.0	986.9
1,960.0	983.8	1,960.0	1,000.3	1,960.0	991.5
1,970.0	988.4	1,970.0	1,005.0	1,970.0	996.1
1,980.0	992.9	1,980.0	1,009.7	1,980.0	1,000.8
1,990.0	997.5	1,990.0	1,014.5	1,990.0	1,005.4
2,000.0	1,002.0	2,000.0	1,019.2	2,000.0	1,010.0

ATTACHMENT 2

EDG 31, 32, 33 Original Test Data From WEDCO Purchase Order 9321-01-102-1

Attachment 2

EDG 31

SQC 246 Rev. A

TEST		Chk'r
INSULATION RESISTANCE		
High Voltage Circuits		
Phase #1	____ Megohms	
Phase #2	____ Megohms	
Phase #3	____ Megohms	
High Potential	____ Volts	
Low Voltage Circuits		
Phase #1	____ Megohms	
Phase #2	____ Megohms	
Phase #3	____ Megohms	
High Potential	____ Volts	
Direct Current Control Circuits		
	____ Megohms	
High Potential	____ Volts	
D.C. Control to A.C. Control		
Phase #1	____ Megohms	
Phase #2	____ Megohms	
Phase #3	____ Megohms	
High Potential	____ Volts	
LUBRICATING OIL		
Main Bearing Filters Applied		
Strainer Element (150 Mesh)		J.B.
Filter Elements Applied		J.B.
Circulation	60 Minutes	J.B.
Level - Full		J.B.
Pre Lube Before Engine Start.		J.B.

TEST	Chk'r
SUPPLIES	
Cooling Water - Fill	J.B.
Diesel Engine Governor Oil	A.Y.
Air Compressor Lube Oil	—
Air Compressor Engine Lube Oil	—
Radiator Fan Gear Unit Lube Oil	—
SEQUENCE	
Pre Lube Pump	J.M.
Jacket Water Heaters	J.M.
Lubricating Oil Heaters	J.M.
Fuel Oil Pump #1	—
Fuel Oil Shut Off Solenoid	—
Fuel Oil Pump #2	—
Air Compressor Motor	—
Crankcase Exhaust Motor	J.M.
Hood Lights	—
Hood Convenience Outlets	—
Starting	J.M.
Automatic Start	J.M.
Warning Alarm and Lights	—
In Attended Selection	J.M.
In Automatic Selection	J.M.
Engine Shutdown	—
In Attended Selection	J.M.
In Automatic Selection	—
Overspeed Trip Switch	J.M.

Order No. 35311-4 Serial No. — Engine Ser. 9733

Customer United Engineers & Constructors

ALCO	Quality Control Department	Power Pak Test Report Sheet 1 of 5 Date 1-6-71

Attachment 2

EDG 31

SQC 246 Rev. A

TEST			Chk'r
PRESSURE SWITCHES			
Compressor Cut In	—	PSI	
Cut Out	—	PSI	
Safety Valve	—	PSI	
~~Fuel Pressure~~ Jacket Water Switch #1			
Stops Prelube Pump	12	PSI	
Starts Crankcase Exh.	12	PSI	P.D.B.
Fuel Pressure Switch #2	—	PSI	—
Low Oil Pressure Switch	60	PSI	P.D.B.
TEMPERATURE SWITCHES			
Automatic Start	—	°F	
Automatic Stop	—	°F	
Jacket Water Heater - On	120	°F	
Off	115	°F	P.D.B.
Lube Oil Heater - On	120	°F	
Off	115	°F	
Hot Engine Shut Down	—	°F	
VOLTAGE CHECKS			
Motor Circuits	440	Volts	J.M.
Heater Circuits	440	Volts	J.M.
Light Circuits	—	Volts	
Outlet Circuits	—	Volts	
Motor Control Circuit	—	Volts	
Alarm Circuits	125 DC	Volts	J.M.
Remote Control Circuit	125 DC	Volts	J.M.
Battery Circuits	125DC	Volts	J.M.
Shutter Control	—	Volts	
Engine Governor	125 DC	Volts	J.M.

TEST			Chk'r
NO LOAD DATA			
Fuel Oil Header Press.	60	PSI	
Lube Oil Header Press.	92	PSI	
Water Outlet Temp.	—	°F	P.B.B.
Engine RPM	900	RPM	
Crankcase Vacuum	1.7	"H_2O	
Lube Oil Outlet Temp.	—	°F	
Overspeed Trip #1	1090	RPM	
#2	1090	RPM	
#3	1090	RPM	
Full Load to No Load	—	RPM	
Stabilizes In	—	Sec.	
Full Load to 75% Load	—	RPM	
Stabilizes In	—	Sec.	
~~Fuel Rack Stop Set~~	—	KW	—
Removed For DEAD LOAD Pickup			

Order No. 35211-4 Quality Control Department _____

Attachment 2

EDG 31

SQC 246 Rev. A

LOAD TEST DATA		1/4	1/2	3/4	4/4	Peak	
Duration of Reading Mins.		30	30	30	60	30	
Ambient Temperature - °F		85	87	90	90	85	
Barometric Pressure - "Hg		30.14	30.14	30.14	30.14	30.16	
Fuel Rack Position - mm		4.5	17	22	23.75	25.5	
Diesel Engine RPM		900	900	900	900	900	
Compressor Outlet Temperature - °F		128	195	240	290	320	
Air Manifold Temperature - °F		135	140	120	145	170	
Exhaust Stack Temperature - °F		640	780	920	840	550	
Jacket Water Inlet Temperature - °F		140	140	136	136	145	
Jacket Water Outlet Temperature - °F		165	165	168	168	167	
Aftercooler Water Inlet Temperature - °F		—	—	—	—	—	
Aftercooler Water Outlet Temperature - °F		—	—	—	—	—	
Lube Oil Inlet Temperature - °F		165	165	165	165	165	
Lube Oil Outlet Temperature - °F		177	178	180	180	180	
Turbine Gas Inlet Pipe Temperature - °F	Upper Right	700	890	970	1040	1060	
	Upper Left	740	900	1010	1030	1110	
	Lower Right	740	930	980	1060	1050	
	Lower Left	740	890	980	1080	1050	
Turbine Gas Inlet Pipe Pressure - "Hg	Upper Right	—	—	—	—	—	
	Upper Left	—	—	—	—	—	
	Lower Right	—	—	—	—	—	
	Lower Left	—	—	—	—	—	
Turbo - Exhaust Outlet Pressure - "H_2O		—	—	—	—	—	
Air Manifold Pressure - PSI		7	7.5	12.5	18.5	22	
Compressor Inlet Pressure - "H_2O (Vac)		2.4	4	7.4	11.5	13.5	
Compressor Discharge Pressure - "Hg		6.9	14.9	25.1	38	44.7	
Crankcase Vacuum - "H_2O		1.5	1.6	1.0	.7	.5	
Lube Oil Header Pressure - psi		84	85	85	85	85	
Fuel Oil Header Pressure - psi		60	60	56	41	29.5	
Water Pump Discharge Pressure - psi		31	31.5	31.5	31.5	31.5	
Lube Oil Pump Discharge Pressure - psi		—	—	—	—	—	
Exhaust Appearance		Haze	Haze	Haze	Haze	Haze	

Approved for Manufacturing R. Bellamy Date 1-6-71

Approved for Quality Control Manager D. A. Burgos Date 1-7-71

ALCO

Order No 35211-4 Quality Control Department

Attachment 2

EDG 31

SQC 246 Rev. A

LOAD TEST DATA	1/4	1/2	3/4	4/4	Peak
Generator Bearing Temperature	—	—	—	—	—
Stator Temperature	—	—	—	—	—
Generator Exhaust Air Temperature	—	—	—	—	—
Generator Frequency - Cycles per Second	60	60	60	60	60
Generator Efficiency in %	89.9	94.5	95.8	96.5	96.5
Power Factor	1.	1.	1.	1.	1.
Exciter Voltage - Volts	52	60	65	70	72
Exciter Current - Amps	60	65	72	80	85
Generator Voltage Line 1-2 Volts	480	480	475	475	480
Line 2-3 Volts	480	480	480	480	480
Line 3-1 Volts	480	480	475	475	475
Generator Current Phase #1 - Amps	575	1105	1625	2140	2400
Phase #2 - Amps	575	1075	1600	2100	2370
Phase #3 - Amps	550	1080	1600	2125	2380
Kilowatts	470	903	1339	1765	1986
Generator Efficiency x 746	670.1	709.9	714.7	719.9	719.8
Brake Horsepower	716	1281	1870	2452	2759
Gross Horsepower	—	—	—	—	—
Fuel Consumed - Lbs/HR	312	498	694	896	1000
Fuel Consumption Lbs/BHP/HR.	.436	.389	.371	.365	.363
	—	—	—	—	—
Exciter Control Current	1.55	1.92	1.95	1.95	1.99

Approved for Manufacturing [signature] Date 1-6-71

Approved for Quality Control Manager D. A. Grayson Date 1-7-71

ALCO

Order No. 35711-4 Quality Control Department

Sheet 4 of 5

Attachment 2
EDG 31

SQC 246.Rev.A

CYLINDER NO.	CYLINDER PRESSURE (psi)		CYLINDER TEMPERATURE °F					
	COM-PRESSION	FIRING	1/4	1/2	3/4	4/4	Peak	
#1 Right		1540	600	650	720	760	800	
#2 Right		1520	590	660	700	750	780	
#3 Right		1580	600	700	740	800	820	
#4 Right		1520	560	710	710	780	790	
#5 Right		1520	600	650	720	770	790	
#6 Right		1530	590	670	730	780	805	
#7 Right		1510	560	640	700	760	780	
#8 Right		1500	580	650	720	790	740	
#1 Left		1550	660	720	780	700	800	
#2 Left		1540	630	850	880	940	960	
#3 Left		1550	710	850	910	980	1610	
#4 Left		1540	740	940	945	1030	1060	
#5 Left		1530	770	830	950	1000	1010	
#6 Left		1500	770	910	1000	1065	1120	
#7 Left		1560	800	900	1000	1050	1100	
#8 Left		1560	640	960	940	1000	1020	

REMARKS

Approved for Manufacturing [signature] Date 1-6-71

Approved for Quality Control Manager D. A. Keegan Date 1-7-71

ALCO

Order No. 35211-4 Quality Control Department

Sheet 5 of 5

Attachment 2
EDG 32

SQC 248 Rev. A

TEST	Chk'r
INSULATION RESISTANCE	
High Voltage Circuits	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
Low Voltage Circuits	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
Direct Current Control Circuits	
____ Megohms	
High Potential ____ Volts	
D.C. Control to A.C. Control	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
LUBRICATING OIL	
Main Bearing Filters Applied	—
Strainer Element (150 Mesh)	J.B.
Filter Elements Applied	J.B.
Circulation 60 Minutes	J.B.
Level - Full	J.B.
Pre Lube Before Engine Start.	J.B.

TEST	Chk'r
SUPPLIES	
Cooling Water - Fill	J.B.
Diesel Engine Governor Oil	A.Y.
Air Compressor Lube Oil	—
Air Compressor Engine Lube Oil	—
Radiator Fan Gear Unit Lube Oil	—
SEQUENCE	
Pre Lube Pump	J.M.
Jacket Water Heaters	J.M.
Lubricating Oil Heaters	J.M.
Fuel Oil Pump #1	—
Fuel Oil Shut Off Solenoid	—
Fuel Oil Pump #2	—
Air Compressor Motor	—
Crankcase Exhaust Motor	J.M.
Hood Lights	—
Hood Convenience Outlets	—
Starting	J.M.
Automatic Start	J.M.
Warning Alarm and Lights	—
In Attended Selection	J.M.
In Automatic Selection	
Engine Shutdown	—
In Attended Selection	J.M.
In Automatic Selection	
Overspeed Trip Switch	J.M.

Order No. 35711-6 Serial No. — Engine Ser. 9735

Customer United Engineers & Constructors

ALCO	Quality Control Department	Power Pak Test Report Sheet 1 of 5 Date 2-5-71

Attachment 2

EDG 32

TEST		Chk'r
PRESSURE SWITCHES		
Air Compressor Cut In	___ PSI	
Cut Out	___ PSI	
Safety Valve	___ PSI	
Jacket Water Fuel ~~Pressure~~ Switch #1		
Stops Prelube Pump	12 PSI	
Starts Crankcase Exh.	12 PSI	J.M.
Fuel Pressure Switch #2	— PSI	
Low Oil Pressure Switch	60 PSI	J.M.
TEMPERATURE SWITCHES		
Automatic Start	— °F	
Automatic Stop	— °F	
Jacket Water Heater - On	120 °F	J.M.
Off	115 °F	
Lube Oil Heater - On	120 °F	
Off	115 °F	
Hot Engine Shut Down	— °F	
VOLTAGE CHECKS		
Motor Circuits	440 Volts	J.M.
Heater Circuits	440 Volts	
Light Circuits	— Volts	
Outlet Circuits	— Volts	
Motor Control Circuit	— Volts	
Alarm Circuits	125DC Volts	
Remote Control Circuit	125DC Volts	
Battery Circuits	125DC Volts	
Shutter Control	— Volts	
Engine Governor	125DC Volts	

TEST		Chk'r
NO LOAD DATA		
Fuel Oil Header Press.	60 PSI	
Lube Oil Header Press.	92 PSI	
Water Outlet Temp.	— °F	
Engine RPM	900 RPM	
Crankcase Vacuum	1.5 "H_2O	
Lube Oil Outlet Temp.	— °F	
Overspeed Trip #1	1080 RPM	
#2	1080 RPM	
#3	1080 RPM	
Full Load to No Load	___ RPM	
Stabilizes In	___ Sec.	
Full Load to 75% Load	___ RPM	
Stabilizes In	___ Sec.	
~~Fuel Rack Step Set~~	___ KW	—
Removed for Dead load Pick up		

Order No. 35211-6 Quality Control Department _____

Attachment 2

EDG 32

LOAD TEST DATA		100%	90%	75%	50%	25%
Duration of Reading - Hrs.		60	30	30	30	30
Ambient Temperature - °F		82	85	85	85	90
Barometric Pressure - "Hg		29.93	29.93	29.94	29.95	29.95
Fuel Rack Position - mm		26.5	22	22	17	12
Diesel Engine RPM		900	900	900	900	900
Compressor Outlet Temperature - °F		358	280	217	160	117
Air Manifold Temperature - °F		132	135	120	100	120
Exhaust Stack Temperature - °F		815	850	840	780	610
Jacket Water Inlet Temperature - °F		140	140	140	140	150
Jacket Water Outlet Temperature - °F		165	165	165	165	165
Aftercooler Water Inlet Temperature - °F		—	—	—	—	—
Aftercooler Water Outlet Temperature - °F		—	—	—	—	—
Lube Oil Inlet Temperature - °F		165	165	165	165	165
Lube Oil Outlet Temperature - °F		180	180	180	180	175
Turbine Gas Inlet Pipe Temperature - °F	Upper Right	1045	1085	980	900	720
	Upper Left	1035	1090	960	895	695
	Lower Right	1000	1090	940	860	680
	Lower Left	1020	1065	970	900	720
Turbine Gas Inlet Pipe Pressure - "Hg	Upper Right	—	—	—	—	—
	Upper Left	—	—	—	—	—
	Lower Right	—	—	—	—	—
	Lower Left	—	—	—	—	—
Turbo - Exhaust Outlet Pressure - "H2O		—	—	—	—	—
Air Manifold Pressure - PSI		18.5	21.75	12.5	7.	3
Compressor Inlet Pressure - "H2O (Vac)		—	—	—	—	—
Compressor Discharge Pressure - "Hg		37.8	44.6	24.8	14.2	6.5
Crankcase Vacuum - "H2O		.9	.8	1.0	1.2	1.2
Lube Oil Header Pressure - psi		52	52	52	52	52
Fuel Oil Header Pressure - psi		45	36	45	150	53
Water Pump Discharge Pressure - psi		32.5	32.5	32.5	32.5	32.5
Lube Oil Pump Discharge Pressure - psi		—	—	—	—	—
Exhaust Appearance		Haze	Haze	Haze	Haze	Haze

Approved for Manufacturing [signature] Date 2-10-71

Approved for Quality Control Manager D. A. Strayer Date 2-11-71

ALCO

Order No 35711-6 Quality Control Department

SHEET 3 OF 5

Sheet 3 of 5

Attachment 2

EDG 32

LOAD TEST DATA	60%	50%	75%	100%	25%
Generator Bearing Temperature	—	—	—	—	—
Stator Temperature	—	—	—	—	—
Generator Exhaust Air Temperature	—	—	—	—	—
Generator Frequency - Cycles per Second	60	60	60	60	60
Generator Efficiency in %	96.5	96.5	95.8	94.5	84.9
Power Factor	1.	1.	1.	1.	1.
Exciter Voltage - Volts	70	75	65	60	55
Exciter Current - Amps	77	80	70	63	57
Generator Voltage Line 1-2 Volts	450	480	450	450	450
Line 2-3 Volts	450	450	480	480	480
Line 3-1 Volts	450	480	450	450	450
Generator Current Phase #1 - Amps	2480	2325	1600	1090	540
Phase #2 - Amps	2100	2350	1575	1090	550
Phase #3 - Amps	2100	2375	1625	1100	550
Kilowatts	1745	1816	1530	908	455
Generator Efficiency x 746	719.9	719.9	714.7	704.9	670.7
Brake Horsepower	2423	2731	1761	1208	678
Gross Horsepower	—	—	—	—	—
Fuel Consumed - Lbs/Hr.	897	1010	694	502	294
Fuel Consumption Lbs/BHP/Hr.	.370	.370	.374	.390	.437
Exciter Control Current AMPS.	1.99	1.95	1.95	1.92	1.85

Approved for Manufacturing [signature] Date 2-10-71

Approved for Quality Control Manager [signature] Date 2-11-71

ALCO

Order No. 25211-6 Quality Control Department

Attachment 2
EDG 32

SQC 246 Rev. A

CYLINDER NO.	CYLINDER PRESSURE (psi)		CYLINDER TEMPERATURE °F					
	COM-PRESSION	FIRING	100%	PEAK	75%	50%	25%	
#1 Right	400	1575	770	765	700	650	570	
#2 Right	390	1500	740	780	720	670	570	
#3 Right	400	1550	755	830	740	700	550	
#4 Right	400	1475	770	810	750	710	610	
#5 Right	375	1575	780	840	735	700	600	
#6 Right	375	1535	760	800	720	695	575	
#7 Right	375	1575	785	815	730	680	560	
#8 Right	375	1550	775	805	710	655	535	
#1 Left	400	1575	810	850	780	755	660	
#2 Left	400	1500	900	940	840	780	650	
#3 Left	390	1550	910	960	860	800	675	
#4 Left	400	1590	950	980	870	830	650	
#5 Left	355	1550	960	985	870	820	730	
#6 Left	400	1590	1020	1075	910	840	700	
#7 Left	350	1575	970	1005	925	850	675	
#8 Left	370	1550	1000	1040	965	880	730	

REMARKS

Approved for Manufacturing [signature] Date 3-10-71

Approved for Quality Control Manager [signature] Date 3-11-71

ALCO

Order No. 75211-6 Quality Control Department

Sheet 5 of 5

Attachment 2
EDG 33

SQC 246 Rev.A

TEST	Chk'r
INSULATION RESISTANCE	
High Voltage Circuits	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
Low Voltage Circuits	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
Direct Current Control Circuits	
____ Megohms	
High Potential ____ Volts	
A.C. Control to A.C. Control	
Phase #1 ____ Megohms	
Phase #2 ____ Megohms	
Phase #3 ____ Megohms	
High Potential ____ Volts	
LUBRICATING OIL	
Main Bearing Filters Applied	—
Strainer-Element (150 Mesh)	J.B.
Filter Elements Applied	J.B.
Circulation 60 Minutes	J.B.
Level - Full	J.B.
Pre Lube Before Engine Start.	J.B.

TEST	Chk'r
SUPPLIES	
Cooling Water - Fill	J.B.
Diesel Engine Governor Oil	A.Y.
Air Compressor Lube Oil	—
Air Compressor Engine Lube Oil	—
Radiator Fan Gear Unit Lube Oil	—
SEQUENCE	
Pre Lube Pump	J.M.
Jacket Water Heaters	J.M.
Lubricating Oil Heaters	J.M.
Fuel Oil Pump #1	—
Fuel Oil Shut Off Solenoid	—
Fuel Oil Pump #2	—
Air Compressor Motor	—
Crankcase Exhaust Motor	J.M.
Hood Lights	—
Hood Convenience Outlets	—
Starting	J.M.
Automatic Start	J.M.
Warning Alarm and Lights	—
In Attended Selection	J.M.
In Automatic Selection	J.M.
Engine Shutdown	—
In Attended Selection	J.M.
In Automatic Selection	
Overspeed Trip Switch	J.M.

Order No. 35211-5 Serial No. — Engine Ser. 9734

Customer United Engineers & Constructors

ALCO | Quality Control Department | Power Pak Test Report Sheet 1 of 5 Date 1-20-71

Attachment 2

EDG 33

SQC 246 Rev. A

TEST		Chk'r
PRESSURE SWITCHES		
Compressor Cut In	— PSI	
Cut Out	— PSI	
Safety Valve	— PSI	
Jacket Water Fuel Pressure Switch #1		
Stops Prelube Pump	12 PSI	
Starts Crankcase Exh.	12 PSI	J.M.
Fuel Pressure Switch #2	— PSI	—
Low Oil Pressure Switch	60 PSI	J.M.
TEMPERATURE SWITCHES		
Automatic Start	— °F	
Automatic Stop	— °F	
Jacket Water Heater - On	120 °F	
Off	115 °F	J.M.
Lube Oil Heater - On	120 °F	
Off	115 °F	
Hot Engine Shut Down	— °F	
VOLTAGE CHECKS		
Motor Circuits	440 Volts	
Heater Circuits	440 Volts	
Light Circuits	— Volts	
Outlet Circuits	— Volts	J.M.
Motor Control Circuit	— Volts	
Alarm Circuits	125DC Volts	
Remote Control Circuit	125DC Volts	
Battery Circuits	125DC Volts	
Shutter Control	— Volts	
Engine Governor	125DC Volts	

TEST		Chk'r
NO LOAD DATA		
Fuel Oil Header Press.	60 PSI	
Lube Oil Header Press.	82 PSI	
Water Outlet Temp.	— °F	
Engine RPM	900 RPM	J.M.
Crankcase Vacuum	1.3 "H_2O	
Lube Oil Outlet Temp.	— °F	
Overspeed Trip #1	1095 RPM	
#2	1095 RPM	
#3	1085 RPM	
Full Load to No Load	— RPM	
Stabilizes In	— Sec.	
Full Load to 75% Load	— RPM	
Stabilizes In	— Sec.	
~~Fuel Rack Stop Set~~	— KW	
Removed for Dead load pick up		

Order No 35211-5 Quality Control Department _____

Attachment 2
EDG 33

LOAD TEST DATA		100%	75%	25%	50%	25%
Duration of Reading MINS		60	30	30	30	30
Ambient Temperature - °F		88	90	90	89	89
Barometric Pressure - "Hg		30.00	30.02	30.01	30.01	30.02
Fuel Rack Position - mm		26	29	22	17	12
Diesel Engine RPM		900	900	900	900	900
Compressor Outlet Temperature - °F		230	245	215	160	130
Air Manifold Temperature - °F		160	169	130	130	130
Exhaust Stack Temperature - °F		790	800	780	720	620
Jacket Water Inlet Temperature - °F		140	142	141	155	156
Jacket Water Outlet Temperature - °F		166	167	167	165	165
Aftercooler Water Inlet Temperature - °F		—	—	—	—	—
Aftercooler Water Outlet Temperature - °F		—	—	—	—	—
Lube Oil Inlet Temperature - °F		167	161	170	170	170
Lube Oil Outlet Temperature - °F		177	178	176	175	175
Turbine Gas Inlet Pipe Temperature - °F	Upper Right	1010	1070	980	900	710
	Upper Left	1010	1075	990	880	730
	Lower Right	1010	1075	990	910	710
	Lower Left	1010	1080	1000	910	742
Turbine Gas Inlet Pipe Pressure - "Hg	Upper Right	—	—	—	—	—
	Upper Left	—	—	—	—	—
	Lower Right	—	—	—	—	—
	Lower Left	—	—	—	—	—
Turbo - Exhaust Outlet Pressure - "H2O		—	—	—	—	—
Air Manifold Pressure - PSI		19	23	15.5	8	4
Compressor Inlet Pressure - "H2O (Vac)		11.4	14	6.8	4.2	2.4
Compressor Discharge Pressure - "Hg		39.2	46.5	25.6	15.2	6.8
Crankcase Vacuum - "H2O		.8	.4	.7	1.0	1.0
Lube Oil Header Pressure - psi		82	82	82	82	82
Fuel Oil Header Pressure - psi		42	38	46	49	53
Water Pump Discharge Pressure - psi		31	31	31	31	31
Lube Oil Pump Discharge Pressure -		—	—	—	—	—
Exhaust Appearance		Haze	Haze	Haze	Haze	Haze

Approved for Manufacturing E.O. Bellamy Date 1-20-71

Approved for Quality Control Manager D. A. Keegan Date 1-21-71

KL00

Order No. 75211-5 Quality Control Department

Sheet 3 of 5

Attachment 2
EDG 33

SQC 246 Rev. A

LOAD TEST DATA	100%	85%	75%	50%	25%	
Generator Bearing Temperature	-	-	-	-	-	
Stator Temperature	-	-	-	-	-	
Generator Exhaust Air Temperature	-	-	-	-	-	
Generator Frequency - Cycles per Second	60	60	60	60	60	
Generator Efficiency in %	96.5	96.5	95.3	94.5	89.9	
Power Factor	1.	1.	1.	1.	1.	
Exciter Voltage - Volts	67	70	60	55	50	
Exciter Current - Amps	70	75	62	57	52	
Generator Voltage Line 1-2 Volts	478	478	479	479	479	
Line 2-3 Volts	480	480	480	480	480	
Line 3-1 Volts	478	478	478	478	478	
Generator Current Phase #1 - Amps	2130	2380	1575	1060	520	
Phase #2 - Amps	2110	2370	1580	1060	520	
Phase #3 - Amps	2125	2390	1600	1065	525	
Kilowatts	1761	1975	1311	881	433	←
Generator Efficiency x 746	719.9	719.8	714.7	734.9	672	
Brake Horsepower	2446	2744	1834	1250	646	
Gross Horsepower	-	-	-	-	-	
→ Fuel Consumed - Lbs By Hand	898	1010	670	492	290	←
Fuel Consumption Lbs/BHP/HR.	.363	.368	.371	.394	.449	
Exciter Control Current	1.96	1.9	1.98	1.89	1.9	

Approved for Manufacturing Leslie Chaney Date 1-20-71

Approved for Quality Control Manager D. A. Brogan Date 1-21-71

ALCO

Order No 25211-5 Quality Control Department

Sheet 4 of 5

Attachment 2
EDG 33

SQC 246 Rev. A

CYLINDER NO.	CYLINDER PRESSURE (psi)		CYLINDER TEMPERATURE °F					
	COM-PRESSION	FIRING	100%	Rated	75%	50%	25%	
#1 Right	350	1535	760	810	720	670	590	
#2 Right	345	1525	770	840	720	650	600	
#3 Right	350	1580	750	815	700	660	590	
#4 Right	350	1475	770	850	720	670	610	
#5 Right	350	1525	730	800	690	690	570	
#6 Right	350	1475	730	790	700	650	580	
#7 Right	350	1535	750	790	710	650	590	
#8 Right	350	1500	750	810	700	670	590	
#1 Left	350	1550	900	980	840	790	730	
#2 Left	350	1525	950	1010	890	830	750	
#3 Left	370	1535	990	1030	920	860	790	
#4 Left	365	1550	890	960	810	750	700	
#5 Left	370	1575	960	1010	900	850	790	
#6 Left	350	1525	930	990	870	810	770	
#7 Left	350	1550	950	990	900	760	720	
#8 Left	350	1575	940	950	890	790	710	

REMARKS

Approved for Manufacturing [signature] Date 1-20-71

Approved for Quality Control Manager [signature] Date 1-21-71

ALCO

Order No. 35211-5 Quality Control Department

Sheet 5 of 5

ATTACHMENT 3

Excerpt from Reference 6:
Table 4-2. High and Low Heat Value Of Some Typical Diesel Fuel Oils;

Telecon of Discussion with MPR Associates on Diesel Fuel Oil Heat Values

both the high heat value and the low heat value of typical fuel oils. The following evaluation relies on comparisons to the high heat values in BTU/gallon. This standard recognizes that "heating values for a given gravity fuel oil may vary somewhat from those shown...."

Table 4-2. High and Low Heat Value of Some Typical Diesel Fuels [Reference 99]

High and Low Heat Values of Some Typical Diesel Fuel Oils*

Gravity, deg API	Sp. Gravity, at 60 F	Weight Fuel, lb/gallon	High Heat Value		Low Heat Value	
			Btu/lb	Btu/gallon	Btu/lb	Btu/gallon
44	0.8063	6.713	19,860	133,500	18,600	125,000
42	0.8155	6.790	19,810	134,700	18,560	126,200
40	0.8251	6.870	19,750	135,800	18,510	127,300
38	0.8348	6.951	19,680	137,000	18,460	128,500
36	0.8448	7.034	19,620	138,200	18,410	129,700
34	0.8550	7.119	19,560	139,400	18,360	130,900
32	0.8654	7.206	19,490	140,600	18,310	132,100
30	0.8762	7.296	19,420	141,800	18,250	133,300
28	0.8871	7.387	19,350	143,100	18,190	134,600
26	0.8984	7.481	19,270	144,300	18,130	135,800
24	0.9100	7.578	19,190	145,600	18,070	137,100
22	0.9218	7.676	19,110	146,800	18,000	138,300
20	0.9340	7.778	19,020	148,100	17,930	139,600
18	0.9465	7.882	18,930	149,400	17,860	140,900
16	0.9593	7.989	18,840	150,700	17,790	142,300
14	0.9725	8.099	18,740	152,000	17,710	143,600
12	0.9861	8.212	18,640	153,300	17,620	144,900
10	1.000	8.328	18,540	154,600	17,540	146,200

Note: It should be understood that heating values for a given gravity of fuel oil may vary somewhat from those shown in the above table.
*Bureau of Standards, Miscellaneous Publication No. 97; Thermal Properties of Petroleum Products, April 28, 1933.

SG 0.83

SG 0.89

A graph showing the distribution of the ULSD diesel fuel heat content test results in Table 4-1 is included as Figure 4-1. Also plotted in Figure 4-1 are the API gravity and heat content values from Table 4-2. As shown in Table 4-1, MPR evaluated a total of 19 samples of ULSD fuel oil. At the lower range of API gravity, the ULSD fuel had a heat content as much as 2,541 BTU/gallon greater than the reference value of typical fuel oil. This is 1.8% greater heat content at a given API gravity. As the API gravity of the tested ULSD fuel samples increased, the heat content decreased. As shown in Figure 4-1, this is also true for the reference diesel fuel oil. The worst case ULSD fuel sample was found to have a lower heat content by 1,554 BTU/gallon or 1.14% lower. This is the worst case variation in the tested ULSD fuel heat content when compared to the typical diesel fuel reference. As can be seen, six out of 19 data points are below the typical diesel fuel line. On the other hand, more than two thirds of the ULSD test points have greater heat content than typical diesel fuel.

Attachment 3

Notes of Telephone Conversation

With: Mark O'Connell, MPR Associates

Qualifications: Co-author of Technical Report MPR-2980, "Evaluation of Ultra Low Sulfur Diesel Fuel for Use in EDGs"; expert in diesel fuel combustion principles

Date: June 2, 2011

Subject: Question on the use of high or low heating values of diesel fuel oil in the determination of EDG fuel oil consumption and required volumes

Response: The situation at IPEC with respect to the necessity of determining diesel fuel oil consumption and required storage volumes was presented to Mr. O'Connell. It was then explained that during the October 2010 IP3 NRC Component Design Basis Inspection, an issue had been raised with diesel fuel oil heating values and their proper use in consumption calculations.

There are two types of heating values listed in diesel heating value tables, high (gross) and low (net). The question at IPEC, which we could not definitively answer without input from an expert, was which values should be used in the determination of the volume of diesel fuel oil required to operate the EDGs at a certain load for a specified period of time.

Mr. O'Connell stated quite clearly that the low heating value (net heat of combustion) should be employed in this case. He explained in technical terms that this heating value is associated with the actual work of the EDG cylinder. The heat related to condensing the water inherent in the hydrocarbon diesel fuel is not transferrable to work of the engine. Therefore, the high heating value (gross heat of combustion) overestimates the actual energy available for power production by the EDG.

The conversation with Mr. O'Connell was completed with the reiteration by him that to calculate the greatest volume of fuel oil of a known density necessary to run an engine at a specific load for a defined duration, the low heating value (the net heat of combustion) of that fuel oil should be used as an input.

ATTACHMENT 4

Telecon of Discussion with J. Peters (IPEC Chemistry) on Meeting Ultra Low Sulfur Diesel Fuel Oil Standard

Attachment 4

Notes of Telephone Conversation

With: James Peters, IPEC Chemistry Department

Qualifications: Chemistry Supervisor responsible for coordinating the testing and acceptance of Emergency Diesel Generator fuel oil deliveries

Date: September 12, 2011

Subject: Question on IPEC's response to meeting the Ultra Low Sulfur Diesel (ULSD) fuel oil standard mandated by the US Environmental Protection Agency (EPA)

Response: In January 2001 and in June 2004, the US Environmental Protection Agency (EPA) finalized the Clean Diesel Trucks and Buses Rule and the Clean Nonroad Diesel Rule, respectively, with more stringent standards for new diesel engines and fuels. Subsequent to these EPA actions, the NRC issued Information Notice 2006-22, "New Ultra Low Sulfur Diesel Fuel Oil Could Adversely Impact Diesel Engine Performance" on October 12, 2006. Report MPR-2980 entitled "Evaluation of Ultra Low Sulfur Diesel Fuel Oil Use in EDGs" was prepared by MPR Associates for IPEC on December 4, 2006 basically in response to NRC IN 2006-22. The purpose of this report was to technically evaluate the properties of ultra low sulfur diesel (ULSD) oil with respect to their impact on EDG function. In its rule-making schedule, the EPA had mandated that the sulfur content of diesel fuel oil for non-road engine use (eg, EDGs) that is domestically refined after December 1, 2010 had to be maintained to 15 ppm or less. The intent of this standard was to reduce the production of certain types of nitrogen and sulfur-related particulate pollutants during diesel fuel oil combustion.

IPEC must meet the requirements of the ULSD standard. All fuel oil intended for EDG and other diesel generator use received after 12/1/2010 has been ULSD oil. However, because of the Low Sulfur Diesel (LSD) fuel oil with a sulfur limit of 500 ppm currently still stored in the Fuel Oil Storage Tanks and the large oil storage tank located beyond Broadway, the overall type of diesel fuel oil now available to the EDGs is a mixture of ULSD and LSD oils. As this mixture is utilized, the tanks are replenished strictly with ULSD fuel oil. Eventually, all of the EDG fuel oil will meet the ULSD standard.

ENCLOSURE 2 TO NL-12-097

IP-CALC-EG-00217, "EMERGENCY DIESEL GENERATOR STORAGE TANK LEVEL SETPOINTS," REV. 5

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286