FAIRBANKS MORSE ENGINE
an Enpro Industries company

Transmittal Form

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0	08-18-2015	A. Hardesty	J. Rath	S. Kaneps	First Revision
Revision	**Date**	**Originator**	**Reviewer**	**Approval**	**Comments**

Fairbanks Morse Engine
701 White Avenue
Beloit, WI 53511

BF5792

CHANGE RECORD

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0	08-18-2015	all	Initial Release	A. Hardesty

Contents

Replacement of the Diesel Generator in Less than Five Days

1.0 Scope

This study note explains in detail the procedure for removing an installed DUS genset on site and subsequent installation of a replacement genset at the same site within a time frame of five days. The procedure outlines a step-by-step method for removal and replacement, and lists all materials and equipment necessary to perform the operation. Many of the processes described herein are treated in WEF deliverable **WEF-14-DUS-FME01-DRW-0057**, on which the present document is modeled.

2.0 Genset Specifications

General: 12 Cylinder Diesel Engine, model 38TD8-1/8, with 3500 kW Generator

Configuration: In-line, Opposed Piston (24 pistons total)

Orientation: Vertical

Bore: 20.6375 cm

Stroke: 25.40 cm

Displacement: 8496.46 cubic cm (**8.496 liters**) per stroke; 16992.92 cm (**16.993 liters**) per cylinder

Compression ratio: 13.8:1

Firing order: 1, 8, 6, 10, 2, 9, 4, 11, 3, 7, 5, 12

Main bearings: 28 (26 plain, 2 thrust)

Rod bearings: 24

Induction: (1) Rootes-type blower and (2) turbochargers

Dimensions: 424 in X 132 in X 170 in (**1076.96 cm X 335.28 cm X 431.80 cm**)

Gross (Dry) Weight (without fluids): approx. 68.05 short tons (**61733.92 kg**); Operating Weight (with fluids): approx. 71.51 short tons (**64872.78 kg**)

Integral fluid capacities:

- Engine lube oil sump: approx. 340 gallons (**1287.04 liters**)
- Water jacket: approx. 445 gallons (**1684.51 liters**)
- Aftercooler circuit: approx. 100 gallons (**378.54 liters**)
    - **NOTE**: Combined coolant capacity of 545 gallons (**2063.05 liters**) does not include coolant from balance of plant piping.
- Alternator and governor lube oil: 1 – 1.5 gallons (**3.79 – 5.68 liters**) combined

3.0 List of Materials and Equipment

Each installed genset is designated to power cooling pumps for a single reactor. The number of reactors (and therefore, gensets) varies from two to six at each facility. The following list of materials and associated quantities is indicated for each facility, regardless of the number of installed gensets, unless otherwise noted. Standard tools are not included in the list, as it is presumed operations will be performed by qualified and provisioned personnel.

3.1 Equipment

(1) [or more] container(s) with a total fluid capacity of 340 gallons (**1287.04 liters**) for evacuation of engine lube oil

(1) [or more] container(s) with a total fluid capacity of 445 gallons (**1684.51 liters**) for evacuation of jacket water coolant

(1) [or more] container(s) with a total fluid capacity of 100 gallons (**378.54 liters**) for evacuation of coolant from the aftercooler circuit

(1) external pump with a dedicated power supply adapted for evacuation of lube oil from the sump

(1) length of hose of ≥ 20 ft (**6.10 m**) suitable for use with external pump

(8) standard **Hillman®** track rollers, **model 15-NT**, and associated tube spacers

(34) **Hillman®** segmented C-channels (FME drawing No. 11880629; FME part No. 11880631), to be assembled into tracks to work with **Hillman®** track roller assembly

(20) **Hillman®** C-channel track support assemblies for insertion between tap pads (FME drawing No. 11880630; FME part No. 11880624)

(18) 144.0 X 10.0 X 2.0 in (**365.76 X 25.4 X 5.08 cm**) construction grade wood boards to serve as substrates underlying the assembled **Hillman®** C-channel tracks

(1) heavy equipment dolly or creeper for transport of **Hillman®** C-channel track segments and track supports to tap pads

(1) length of rope ≥ 200 ft (**61 m**) nominally rated at ≥ 5 short tons (**4535.92 kg**) to be cut for sundry manual pulling operations or (4) comparable tie-down straps

(1) portable winch capable of ≥ 5 short tons (**4535.92 kg**) of drawing force to be used for genset extraction

(2) hydraulic lift brackets (FME part No. 11880477)

(1) hydraulic lift bracket (FME part No. 11880478)

(1) hydraulic lift bracket (FME part No. 11880423)

(1) hydraulic lift bracket (FME part No. 11880473)

(1) hydraulic lift with a nominal rating of ≥ 100 short tons (**90718.50 kg**)

(5) hydraulic rams to interface between hydraulic lift and each of the five contact points on installed lift brackets, each ram with a nominal rating of ≥ 20 short tons (**18143.70 kg**)

(1) **Bushman®** model 439-3 three point counterweighted lift bar (or comparable substitute) nominally rated at 37 short tons (**33565.80 kg**)

(1) **Bushman®** model 439 two point lift bar (or comparable substitute) nominally rated at 40 short tons (**36287.40 kg**)

(1) strapping or cabling apparatus with a maximum load rating of ≥ 37 short tons (**33565.80 kg**) for attachment of genset at hardened lift points on skid to three point lift bar

(1) strapping or cabling apparatus with a maximum load rating of ≥ 40 short tons (**36287.40 kg**) for attachment of genset at hardened lift points on skid to two point lift bar

(1) strapping or cabling apparatus with an aggregate tensile rating of ≥ 80 short tons (**72574.80 kg**) for attachment of lift bars to crane

(1) lift shackle for use with rope or strapping suitable for use as a winch attachment point

(1) pint (**473.176 ml**) of lubricating grease for use on guide pins for genset placement operations

3.2 Hardware

The following hardware items are to be delivered to the installation site as part of an attachment hardware package, prepared by FME.

(26) **M10 x 1.5 – 40** hex bolts for attachment of **Hillman®** track rollers to tube spacers

- (24) for in-service
- (2) as spares

(26) **M10 x 1.5 – 40** hex nuts for attachment of **Hillman®** track rollers to tube spacers

- (24) for in-service
- (2) as spares

(36) **M24 x 3 – 75** hex bolts for attachment of **Hillman®** rollers to skid

- (32) for in-service
- (4) as spares

(36) **M24 x 3 – 75** hex nuts for attachment of **Hillman®** rollers to skid

- (32) for in-service
- (4) as spares

(4) **M24 x 3 – 90** hex bolts for securing **Hillman®** C-channel tracks to tap pads

(18) **M24 x 3 – 60** (total length: **230 mm**) hex head bolts to be used as guide pins for genset placement

(36) **M24 – 40** lag bolts for securing **Hillman®** C-channel tracks to wood substrates

- (32) for in-service
- (4) as spares

4.0 Genset Removal Procedure

Before the genset can be extracted from the building, all piping, wiring, and other interfaces between the genset and the building must be disconnected. Where practicable, disconnection of any peripheral attachment should be performed at a union closest to the genset itself, specified in the lists which follow. Exogenous cooling water, lube oil, and fuel must be drained from system piping and/or reservoirs before proceeding with piping system disconnection.

- **NOTE**: Though fully contained by the genset, endogenous jacket water and lube oil should also be drained before genset extraction to reduce net weight and alleviate lifting stresses on extraction equipment and attachment hardware. Steps for extraction of the genset follow a modified reversal of the steps indicated for genset installation, outlined in **WEF-15-DUS-FME01-DRW-0057**. Proceed as follows:

  1. Evacuate the engine sump of lube oil using the external pump and hose routed through the lube oil replenishment intake (See **Fig. B-19**).

  2. Drain the water jacket of coolant, disconnecting at the jacket water drain line coupling (See **Fig. B-14**). Also drain coolant from the aftercooler, disconnecting at the aftercooler drain line coupling (See **Fig. B-13**). Gravity feed draining is acceptable for evacuating coolant from both systems.

  3. Disconnect all interfaces between the genset and the facility. In general, these interfaces fall into one of two categories: fluid and electrical. A complete compendium of photos of all interfaces appears in **Appendix B** of the present document. For each list below, letters in parentheses - () - correspond to the symbol nomenclature from the diesel connection locations (interfaces) in the tables extracted from **FME drawing 10561822, revision G**, viewable in **Appendix A**.

  For fluid interfaces, disconnect the following:

  - Turbocharger fresh air intake flange (A) See **Fig. B-1**
  - Turbocharger exhaust flange (B) See **Fig. B-2**
  - Jacket water pump suction flange (C) See **Fig. B-3.1** & **3.2**
  - Jacket water engine discharge flange (D) See **Fig. B-4**
  - Air start intake – upper (E1) See **Fig. B-5**
  - Air start intake – lower (E2) See **Fig. B-5**
  - Intercooler pump suction flange (F) See **Fig. B-6**
  - Intercooler water discharge flange (G) See **Fig. B-7**
  - Fuel oil pump suction (J) See **Fig. B-8**
  - Fuel oil pump relief (K) See **Fig. B-8**
  - Fuel oil header return (L) See **Fig. B-9**

- Fuel oil drain tank overflow (M) See **Fig. B-10**
- Fuel oil drain pump discharge (N) See **Fig. B-11.1** & **11.2**
- Lube oil sump drain (P) See **Fig. B-12**
- Aftercooler drain line (Q) See **Fig. B-13**
- Jacket water drain line (R) See **Fig. B-14**
- Jacket water surge line (S) See **Fig. A-15**
- Aftercooler water surge line (T) See **Fig. B-16.1** & **16.2**
- Jacket water vent (W) See **Fig. B-17**
- Aftercooler vent (X) See **Fig. B-18.1** & **18.2**
- Lube oil replenishment intake (Y) See **Fig. B-19**
- Fuel oil tank drain leak off (Z) See **Fig. B-20**
- Fluid waste outlet (A1) See **Fig. B-21**
- Fluid waste outlet (A2) See **Fig. B-22**
- Fluid waste outlet (A3) See **Fig. B-23**

For electrical interfaces, disconnect the following:

- Auxiliary RTD (AA) See **Fig. B-24**
- Engine RTD (upper) (AB) See **Fig. B-24**
- Engine RTD (lower) (AC) See **Fig. B-25**
- K-type thermocouple relay (AD) See **Fig. B-26**
- Loop power “4-20” MA transmitters (AE) See **Fig. B-27**
- Discrete input/output (AF) See **Fig. B-28**
- Governor actuator (AG) See **Fig. B-29**
- Voltage regulator (AH) See **Fig. B-30**
- High voltage (AI) See **Fig. B-31**
- Skid grounding strap (no drawing reference) See **Fig. B-32**
- Alternator grounding strap (no drawing reference) See **Fig. B-33**

4. Transport the segments of the **Hillman®** C-channel tracks using the creeper or dolly and assemble the segments on the floor of the facility near the drive end of the genset. Assemble the segments into two tracks for placement under either side of the genset. Orient each track such that one end faces the genset and the opposite end faces the location outside the building where the genset will be loaded for shipping. To ease placement of the tracks on the tap pads, assemble only as many segments as will fit directly under the genset and on top of the pads (roughly 6 segments). The C-channels are designed to work with the **Hillman®** track roller assemblies, **model 15-NT**, to move the genset and to direct it to or from its installation site inside the building. For a plan view of one partially assembled track as it appears under one side of the genset, see **Fig. 4-1.**

- **NOTE**: The track assembly is "keyed" to align the tap pads along the Y-axis with the genset to allow for precise placement at installation.

- **NOTE**: The complete running length of the fully assembled track is approximately 31 m.

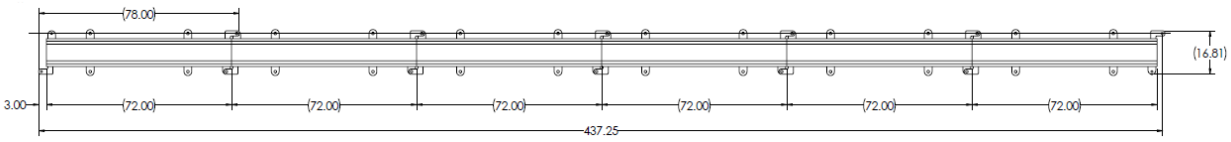


Fig. 4-1

Plan (Aerial) View of Six (6) Assembled Hillman® C-Channel Track Segments. Dimensions Are in Inches.

5. Place the 15 ton (**13607.80 kg**) **Hillman®** rollers on the track assemblies. Fix the spacing of the rollers with spacer tubes to maintain correct position under the skid. Use two (2) **M10 x 1.5 - 40** bolts and nuts to attach each spacer tube end to each roller (24 bolts total, 12 on each side). See **Fig. 4-2** and **4-7**.

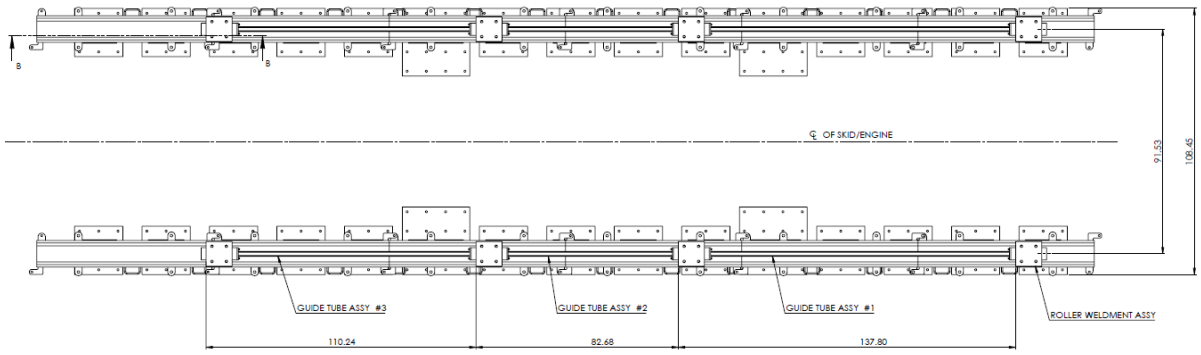


Fig. 4-2

Plan (Aerial) View of Hillman® Roller Assembly Resting on Installed Hillman® C-Channel Track.
Note Unequal Length Spacer Tubes of Roller Assembly and Tap Pads under Track.

6. Attach hydraulic lifting lug Nos. 1 – 5 to the DUS genset skid at the locations indicated in **Fig. 4-3**.

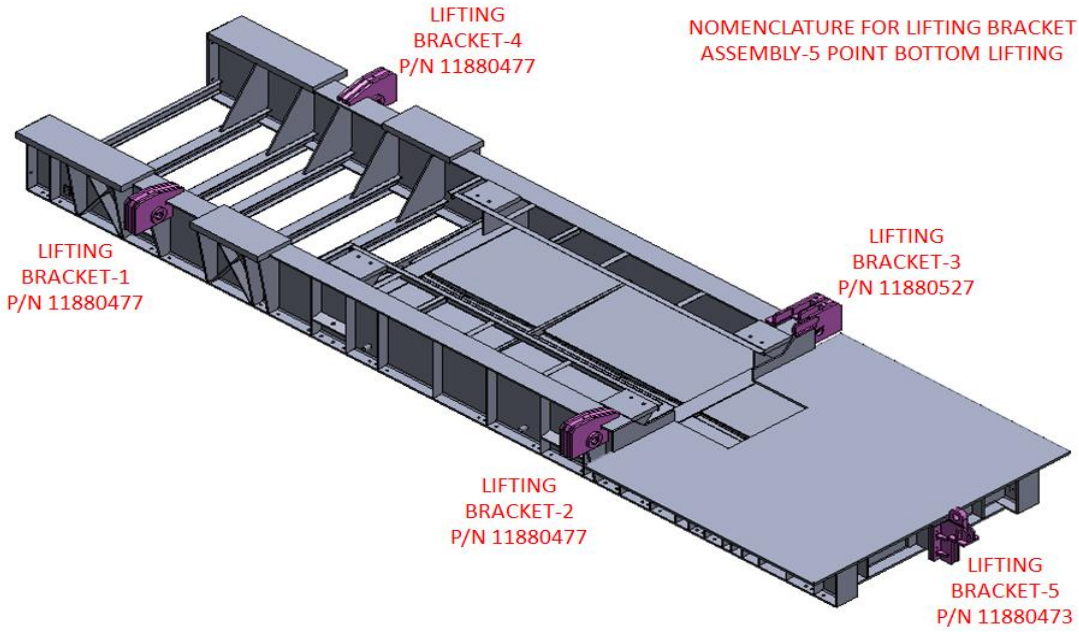


Fig. 4-3

Isometric View of DUS Genset Skid with Detachable Lifting Lugs 1-5 Installed

7. Thread a lift shackle through a crane hoisting strap and run the ends of the strap through hardened lift point Nos. 1 and 3 on the drive end of the skid (See **Fig. 4-4**). Route the strap forward and across the drive end of the skid on the x-axis (not over), from side to side.

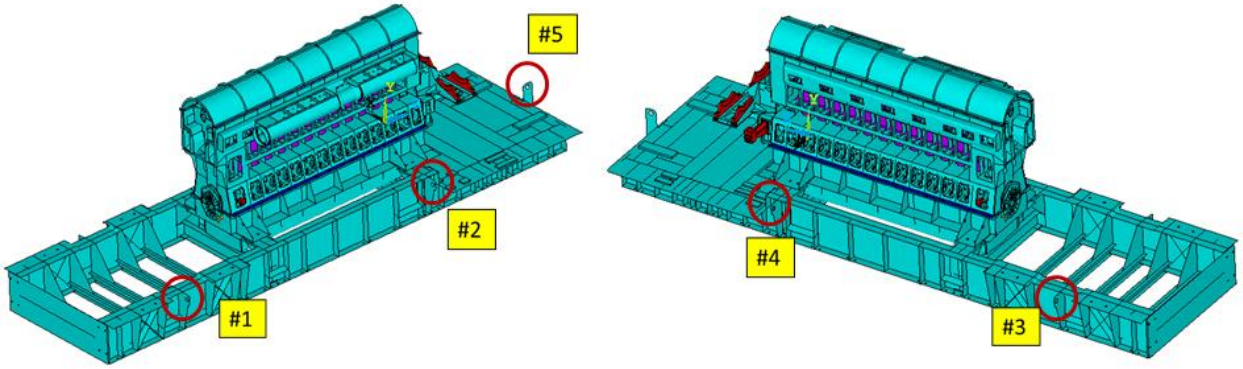


Fig. 4-4

Dual Isometric Views of DUS Genset Skid Showing Hardened Lifting Points 1-4 and Detachable Lug 5

8. Establish a winch placement location on the exterior of the building aligned on the x-axis with the center of the drive end of the genset and on the y-axis with the drive end hardened lift point Nos. 1 and 3 on the skid. Situate the winch at the nearest possible distance to enable complete

extraction of the genset from the building and optimal positioning of the genset for loading by crane onto the shipping conveyance.

9. Remove **ALL** bolts attaching the genset skid to the embedded tap pads in the floor. The genset is secured to the floor with 70 bolts, 35 on each side.

- Remove the **M24 x 3 – 90** mounting bolts (54 total, 27 each side) from the 18 tap pads which use the 2-bolt attachment.
- Remove the **M30 x 3.5 – 90** mounting bolts (16 total, 8 each side) from the four (4) tap pads which use the 4-bolt attachment.

➢ **CAUTION !!!** : Perform a walk-around to verify that **ALL** bolts have been removed prior to initiating jacking operations. If jacking is initiated with one (1) or more bolts still attached, torqueing of the genset skid and imbalance will result.

10. Insert track support assemblies between each tap pad on each side of the genset and align each support with the adjacent tap pads. 10 supports are used per side (See **Fig. 4-5**).

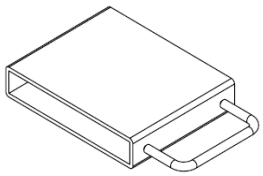


Fig. 4-5
Isometric View of Hillman® C-Channel Track Support

11. Position hydraulic rams under each of the five lift brackets, aligning contact surfaces of the rams with those of the brackets (See **Fig. 4-6**).

➢ **NOTE**: The facility engineer should determine the amount of force per unit area the concrete floor can withstand and, if necessary, deploy force dispersion plates of appropriate thickness and surface area for insertion under each ram before lifting operations are initiated.

➢ **CAUTION**: Hydraulic rams must be linked to one (1) central hydraulic lift to ensure even distribution of jacking force so as to keep the genset level during lifting operations.

Fig. 4-6

Hydraulic Rams Adapted for Placement and Removal of DUS Genset

12. Initiate jacking operations, lifting the genset until the skid is elevated enough to allow for insertion of the **Hillman®** track and roller assemblies under the skid. Each track (side) of the assembly uses four (4) rollers.

13. Insert the **Hillman®** track and roller assemblies under the skid, pushing or pulling the track assembly forward until the assembly rests aligned on top of the tap pads and the attachment holes on the foremost and rearmost ends of the tracks are concentric with the corresponding taps in the foremost (control end) and rearmost (drive end) tap pads.

- **NOTE**: The wall-mounted winch may be used to pull the assembly into place.

- **NOTE**: All rollers rest on the tracks, the first pair (left and right, control end) of which attach to the skid with bolts through holes in the skid and rollers (See **Fig. 4-7**).

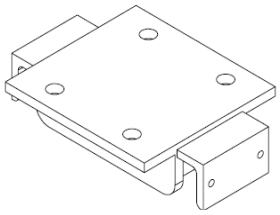


Fig. 4-7

Isometric View of Top Side of Hillman® Roller Showing Mounting Plates with Holes

14. Using the drilled tabs on the track segments, attach each track assembly (both sides of the genset) to the outer taps of the foremost and the rearmost tap pads with **M24 x 3 - 90** mounting bolts at the points indicated in **Fig. 4-8**.

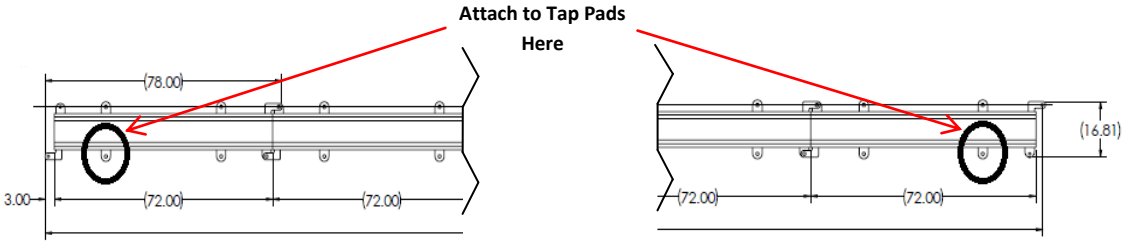


Fig. 4-8

Broken View of Hillman® C-Channel Track Showing Tap Pad Attachment Points

15. Lay two (2) parallel courses of 144.0 X 10.0 X 2.0 in (**365.76 X 25.4 X 5.08 cm**) construction grade wood boards from the tracks at the drive end of the genset to the location outside the building where the genset will be loaded for shipping.

16. Assemble the remaining **Hillman®** C-channel segments, extending the tracks under the genset from the drive end atop the wood courses to where they end outside the building. Maintain alignment of the tracks with the underlying courses.

17. Again using the drilled tabs on the track segments, attach each track assembly to the wood courses with **M24 – 40** lag bolts, fixing each track to two (2) points (one on either side of the track) for each running length of board.

18. Lower the genset in increments to allow for fore-and-aft adjustment of the first pair of rollers on the track until roller and skid holes are concentric.

19. Attach the control end of the skid to the first pair of rollers with four (4) **M24 x 3 – 75** bolts and nuts (See **Fig. 4-7**). Each bolt enters from inside the I-beam of the skid and is secured with a single nut from the underside of the roller. Secure each bolt with a nut and hand tighten. Final tightening will be performed after the full weight of the genset rests on the track assembly.

- **NOTE**: The remaining six (6) rollers of the assembly (3 on each side) are automatically positioned at optimal weight-bearing locations by virtue of the guide tubes (See **Fig. 4-2**). These rollers contact, but do not attach to, the skid.

20. With rollers attached or positioned, gradually lower the genset until all rams have separated from their corresponding mating surfaces on the lift brackets and the full weight of the genset rests on the rollers. Finish tightening the first pair of rollers to the skid.

21. Remove hydraulic rams and lift brackets, except for the No. 5 lift bracket (See **Fig. 5-1**).

22. Attach the winch cable to the shackle on the drive end strap. See step No. 7, above.

23. Ensure that the **Hillman®** C-channels are clear of all debris and that the track path is free of obstructions. Initiate winching to extract the genset from the building. Stop winching when the genset is optimally situated for lifting by crane.

- **NOTE**: C-channels are designed with built-in stops to prevent the genset from derailing.

24. Disconnect the winch from the shackle on the hoisting strap and the hoisting strap from the drive end hardened lift point Nos. 1 and 3 (See **Fig. 4-4**).

25. Loosen and remove the **M24 x 3 – 75** bolts and nuts attaching the first pair of rollers to the control end of the skid.

26. Attach the 37-ton strapping to hardened lift point Nos. 2 and 4 on the control end of the genset skid, and to lift bracket No. 5 on the piping end interface of the skid (See **Fig. 4-4**).

27. Attach the 40-ton strapping to hardened lift point Nos. 1 and 3 on the drive end of the genset skid (See **Fig. 4-4**).

28. Attach the 37-ton strapping to **Bushman® model 439-3** three-point counterweighted (or comparable) lift bar, suspended by crane.

29. Attach the 40-ton strapping to **Bushman® model 439** two-point (or comparable) lift bar, suspended by crane.

30. Initiate genset lifting by crane to place the genset on the shipping conveyance, following all standard crane operation and safety procedures.

31. Lower the genset onto the shipping conveyance and secure the genset for shipping.

5.0 Genset Installation Procedure

In general, genset installation follows a reversal of the steps outlined in section **4.0**.

The replacement genset should be verified to have peripheral connection points identical in type, dimension, location, and connection interface relative to the genset extracted. Any modifications performed to these interfaces after delivery of the genset by FME may require subsequent modification to the genset and/or to the facility interface(s) to permit genset operability following replacement.

If the replacement genset is a used or refurbished unit, verification should be made before installation that performance of the replacement unit has been optimized. Maintenance performed to the replacement genset after installation may delay genset operability. The installation procedure which follows assumes design identicality between the genset extracted and the replacement genset.

The following steps outline the replacement procedure:

1. If the **Hillman®** C-channel tracks are already in place over the tap pads, go to step No. 5. If the tracks are not in place, insert the **Hillman®** track support assemblies between each tap pad on the floor and align each support with the adjacent tap pads. 10 supports are used per side (See **Fig. 4-5**).

2. Transport the segments of the **Hillman®** C-channel tracks using the creeper or dolly and assemble the channel track on the floor of the facility and over the tap pads. Assemble the segments into two (2) tracks and orient the assembly such that one (1) end faces the wall of the building interior and the opposite end faces the location outside the building where the genset will be offloaded from its shipping conveyance.

To ease placement of the tracks on the tap pads, assemble only as many segments as will fit directly above the tap pads (roughly 6 segments). The C-channels are designed to work with **Hillman®** track roller assemblies, **model 15-NT**, to move the genset and to direct it to or from its installation site inside the building. For a plan view of one partially assembled track as it appears above one (1) linear array of tap pads, see **Fig. 4-1**.

3. Align the **Hillman®** C-channel assembly over the tap pads, pushing or pulling the assembly into place until the attachment holes on the outer rail ends are concentric with the corresponding taps on the outside of the foremost (control end) and rearmost (drive end) tap pads.

- **NOTE**: The wall-mounted winch may be used to pull the assembly into place.

4. Using the drilled tabs on the track segments, attach each track assembly (both sides of the genset) to the outer taps of the foremost and the rearmost tap pads with **M24 x 3 - 90** mounting bolts at the points indicated in **Fig. 4-8**.

5. Lay two (2) parallel courses of 144.0 X 10.0 X 2.0 in (**365.76 X 25.4 X 5.08 cm**) construction grade wood boards from the tracks at the drive end of the genset to the location outside the building where the genset will be offloaded.

6. Assemble the remaining **Hillman®** C-channel segments, extending the tracks under the genset from the drive end atop the wood courses to where they end outside the building. Maintain alignment of the tracks with the underlying courses.

7. Again using the drilled tabs on the track segments, attach each track assembly to the wood courses with **M24 – 40** lag bolts, fixing each track to two (2) points (one on either side of the track) for each running length of board.

8. Place the 15 ton (**13607.80 kg**) **Hillman®** rollers on the track assemblies. Fix the spacing of the rollers with spacer tubes to maintain correct position under the skid. Use two (2) **M10 x 1.5 - 40**

bolts and nuts to attach each spacer tube end to each roller (24 bolts total, 12 on each side). See **Fig. 4-2** and **4-7**.

9. Move the roller assembly to within proximity of the genset.

10. If not already in place, attach the No. 5 lift bracket to the piping end interface of the genset skid (See **Fig. 5-1**).

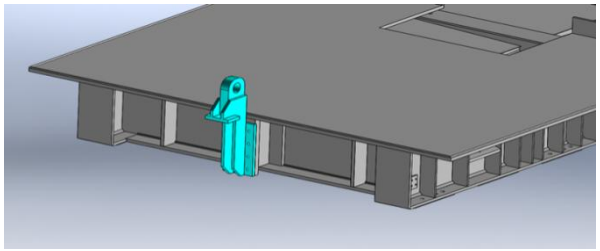


Fig. 5-1
Detachable Lifting Lug No. 5

11. Attach the 37-ton strapping to hardened lift point Nos. 2 and 4 on the control end of the genset skid, and to lift bracket No. 5 on the piping end interface of the skid (See **Fig. 4-4**).

12. Attach the 40-ton strapping to hardened lift point Nos. 1 and 3 on the drive end of the genset skid (See **Fig. 4-4**).

13. Attach the 37-ton strapping to the **Bushman® model 439-3** three-point counterweighted (or comparable) lift bar, suspended by crane.

14. Attach the 40-ton strapping to the **Bushman® model 439** two-point (or comparable) lift bar, suspended by crane.

15. Initiate genset lifting by crane to remove the genset from the shipping conveyance, following all standard crane operation and safety procedures.

16. Guide the genset into place on the roller assembly, adjusting the assembly fore-and-aft until the holes on the first pair of rollers and the holes on the control end of the skid are concentric. Keep the genset elevated to just above the roller assembly for attaching the first pair of rollers to the skid.

- **NOTE**: During lifting and placing, ensure that the genset is oriented with the control end facing the interior of the building and the drive end facing the exterior.

17. Attach the control end of the skid to the first pair of rollers with four (4) **M24 x 3 – 75** bolts and nuts (See **Fig. 4-7**). Each bolt enters from inside the I-beam of the skid and is secured with a single nut from the underside of the roller. Secure each bolt with a nut and hand tighten. Final tightening will be performed after the full weight of the genset rests on the track assembly.

- **NOTE**: The remaining six (6) rollers of the assembly (3 on each side) are automatically positioned at optimal weight-bearing locations by virtue of the guide tubes (See **Fig. 4-2**). These rollers contact, but do not attach to, the skid.

18. With rollers attached or positioned, gradually lower the genset until its full weight rests on the rollers. Finish tightening the first pair of rollers to the skid. Remove the crane lifting apparatus from the genset.

19. Attach the winch cable (mounted on the wall inside the building near the control end of the genset) to the No. 5 lift bracket (See **Fig. 5-1**).

20. Ensure that the **Hillman®** C-channels are clear of all debris and that the track path is free of obstructions. Initiate winching to draw the genset into the building. Stop winching when the attachment holes of the skid are roughly concentric with the corresponding taps in the tap pads.

- **NOTE**: C-channels are designed with built-in stops to prevent the genset from derailing.

21. On each side of the genset, stagger **M24 x 3 - 60** (total length: **230 mm**) guide bolts through the skid mounting holes and thread the bolts into the corresponding tapped holes for those tap pads designed for 2-bolt mounting (See **Fig. 5-2**). Adjust genset placement as needed by rolling fore-and-aft on the C-channels until holes on the skid and the taps are concentric. A total of 18 bolts (1 on each tap pad, 9 on each side) are to be used. Engage all bolts through the full depth of the taps (**51 mm**). The unthreaded part of the shaft of each bolt will preserve concentricity for all holes and will serve to guide the genset into precise position as it is lowered. Unthreaded bolt shafts should be greased to facilitate lowering.

22. Attach hydraulic lift bracket Nos. 1 – 4 to the genset skid at the locations indicated in **Fig. 4-3**.

23. Position hydraulic rams under each of the five lift brackets, aligning contact surfaces of the rams with those of the brackets.

- **NOTE**: The facility engineer should determine the amount of force per unit area the concrete floor can withstand and, if necessary, deploy force dispersion plates of appropriate thickness and surface area for insertion under each ram before lifting operations are initiated.

- **CAUTION**: Hydraulic rams must be linked to one (1) central hydraulic lift to ensure even distribution of jacking force so as to keep the genset level during lifting operations.

24. Disconnect the winch from the No. 5 lift bracket.

25. Loosen and remove the **M24 x 3 – 75** bolts and nuts attaching the first pair of rollers to the control end of the skid.

26. Initiate jacking operations, lifting the genset until the skid is elevated enough to allow for extraction of the **Hillman®** roller assembly under the skid. When finished jacking, remove roller assembly.

27. Remove the **Hillman®** track assembly in segments up to the drive end of the genset, then remove the **M24 x 3 - 90** mounting bolts securing the **Hillman®** C-channels to the tap pads at the points indicated in **Fig. 4-8**. Draw each remaining track length out from under the genset using a winch in a manner similar to that described in step No. 23 of section **4.0**.

28. Slowly lower the genset into place on the tap pads, verifying that the skid moves freely over the guide bolts.

29. Remove hydraulic rams and all lift brackets.

30. Remove the guide bolts from each side of the genset.

31. Replace all bolts attaching the genset skid to the embedded tap pads in the floor. The genset is secured to the floor with 70 bolts, 35 on each side (See **Fig. 5-2**).

- Insert the **M24 x 3 – 90** mounting bolts (54 total, 27 each side) into the 18 tap pads which use the 2-bolt attachment, torqueing each to **620 Nm**.
- Insert the **M30 x 3.5 – 90** mounting bolts (16 total, 8 each side) into the four (4) tap pads which use the 4-bolt attachment, torqueing each to **1300 Nm**.

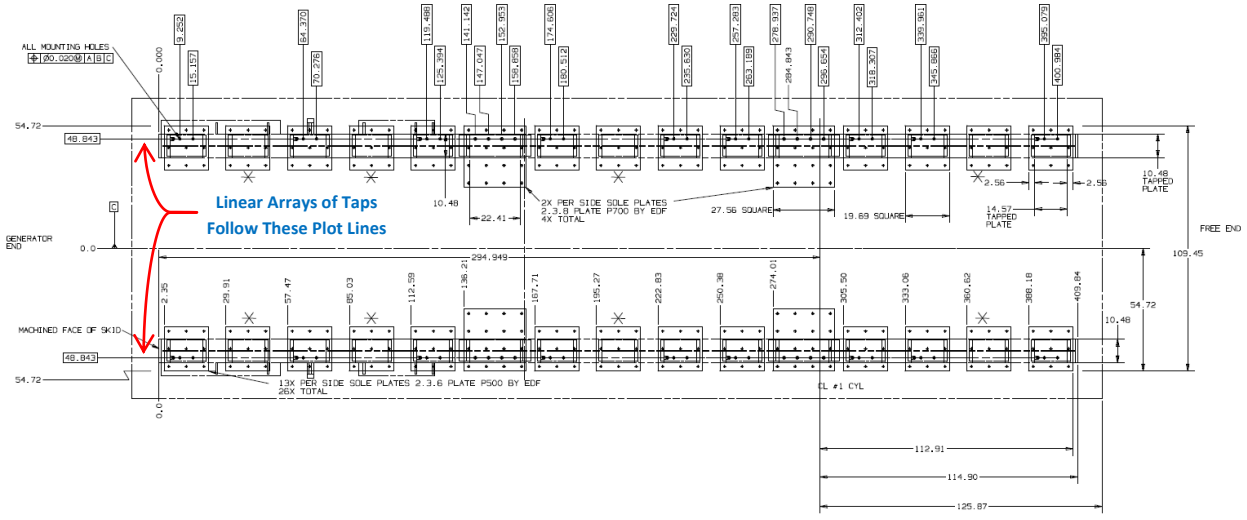


Fig. 5-2

Plan (Aerial) View Showing Tap Pad Locations and Mounting Taps. Pads Marked with an Asterisk (*) Are Not Tapped.

32. Reconnect all interfaces between the genset and the facility.

For fluid interfaces, reconnect the following:

- Turbocharger fresh air intake flange (A) See **Fig. B-1**
- Turbocharger exhaust flange (B) See **Fig. B-2**
- Jacket water pump suction flange (C) See **Fig. B-3.1** & **3.2**
- Jacket water engine discharge flange (D) See **Fig. B-4**
- Air start intake – upper (E1) See **Fig. B-5**
- Air start intake – lower (E2) See **Fig. B-5**
- Intercooler pump suction flange (F) See **Fig. B-6**
- Intercooler water discharge flange (G) See **Fig. B-7**
- Fuel oil pump suction (J) See **Fig. B-8**
- Fuel oil pump relief (K) See **Fig. B-8**
- Fuel oil header return (L) See **Fig. B-9**
- Fuel oil drain tank overflow (M) See **Fig. B-10**
- Fuel oil drain pump discharge (N) See **Fig. B-11.1** & **11.2**
- Lube oil sump drain (P) See **Fig. B-12**
- Aftercooler drain line (Q) See **Fig. B-13**
- Jacket water drain line (R) See **Fig. B-14**
- Jacket water surge line (S) See **Fig. A-15**
- Aftercooler water surge line (T) See **Fig. B-16.1** & **16.2**
- Jacket water vent (W) See **Fig. B-17**
- Aftercooler vent (X) See **Fig. B-18.1** & **18.2**
- Lube oil replenishment intake (Y) See **Fig. B-19**
- Fuel oil tank drain leak off (Z) See **Fig. B-20**
- Fluid waste outlet (A1) See **Fig. B-21**
- Fluid waste outlet (A2) See **Fig. B-22**
- Fluid waste outlet (A3) See **Fig. B-23**

For electrical interfaces, reconnect the following:

- Auxiliary RTD (AA) See **Fig. B-24**
- Engine RTD (upper) (AB) See **Fig. B-24**
- Engine RTD (lower) (AC) See **Fig. B-25**
- K-type thermocouple relay (AD) See **Fig. B-26**
- Loop power “4-20” MA transmitters (AE) See **Fig. B-27**
- Discrete input/output (AF) See **Fig. B-28**
- Governor actuator (AG) See **Fig. B-29**
- Voltage regulator (AH) See **Fig. B-30**
- High voltage (AI) See **Fig. B-31**
- Skid grounding strap (no drawing reference) See **Fig. B-32**
- Alternator grounding strap (no drawing reference) See **Fig. B-33**

33. Refill jacket water and lube oil sump to rated capacity. (See **Fig. B-14** and **B-19** and section **2.0**).

34. Perform on site acceptance testing of the DUS genset if specified in the relevant procedural documentation following installation.

- **NOTE**: On-site testing should not be considered an essential procedural aspect of genset replacement, as testing alone may exceed five days (See ¶ 3 of § **5.0**).

Appendix A

This appendix serves as a catalog of detail views from **FME drawing 10561822, revision G**. It is intended to assist in identifying the location of all designed interfaces between the DUS genset and the facility. Tables of alphanumeric codes (below) which correlate a given interface feature to its corresponding location on or near the genset have been taken from the above drawing and are provided here for ease of reference.

Table A-1

Fluid Interfaces A-M

Alphanumeric symbol in far left column corresponds to interface feature locations in Fig. A-1 – A-4.

DIESEL CONNECTION LOCATIONS (G)				
SYMBOL	DESCRIPTION	LOCATION FROM : CL ENGINE CL CYLINDER #1 CL LWR CRANK	SIZE	REMARKS / SPECIFICATION
A	TURBOCHARGER AIR INLET (FLANGE)	0.00 CS 75.87 FWD 89.37 UP	DN 550	FLANGE, 22" SPS, DN550 PN6 / PER NF J22-215
B	TURBOCHARGER EXHAUST OUT (FLANGE)	11.69 CS 42.76 FWD 118.98 UP	DN 600	FLANGE, DN600 PN6, 1" THK, A36 HR / PER EN 1092-1
C	J. W. PUMP SUCTION (FLANGE)	54.92 CS 115.24 FWD 25.58 UP	DN 150	FLANGE, TYPE B,RF, TYPE 12 DN150 PN16, S235JR / PER EN 1092-1
D	J. W. ENGINE DISCHARGE (FLANGE)	54.92 CS 115.24FWD 73.34 UP	DN 150	FLANGE, TYPE B,RF, TYPE 12 DN150 PN16, S235JR / PER EN 1092-1
E1	STARTING AIR INLET	53.76 OCS 73.63 AFT 22.92 DWN	DN 40	FLANGE, TYPE B,RF, DN40 PN40, X2CrNi19-11 / PER EN 1092-1
E2	STARTING AIR INLET	53.76OCS 73.62 AFT 38.72 DWN	DN 40	FLANGE, TYPE B,RF, DN40 PN40, X2CrNi19-11 / PER EN 1092-1
F	INTERCOOLER PUMP SUCTION (FLANGE)	65.13 ODC 55.93 FWD 51.35 UP	DN 125	FLANGE, TYPE 12 TYPE B,RF DN125 PN16, S235JR / PER EN 1092-1
G	INTERCOOLER WATER DISCHARGE (FLANGE)	65.13 OCS 6.3AFT 51.35 UP	DN 125	FLANGE, TYPE 12 TYPE B,RF DN125 PN16, S235JR / PER EN 1092-1
J	FUEL OIL PUMP SUCTION	65.00 CS 35.25 FWD 13.51 DWN	DN 25	FLANGE, TYPE B,RF TYPE 12, DN25 PN40, P245GH / PER EN 1092-1
K	FUEL OIL PUMP RELIEF	65.00 CS 30.03 FWD 13.51 DWN	DN 25	FLANGE, TYPE B,RF TYPE 12, DN25 PN40, P245GH / PER EN 1092-1
L	FUEL OIL HEADER RETURN	65.00 OCS 3.62 FWD 13.26 DWN	DN 25	FLANGE, TYPE B,RF, TYPE 13(THREADED) G1 DN25 PN40, P245G / PER EN 1092-1
M	FUEL OIL DRAIN TANK OVERFLOW	31.46 CS 148.50 FWD 17.99 DWN	DN 25	FLANGE, RFSO, DN25 PN40 / PER EN 1092-1

Table A-1 (continued)

Fluid Interfaces N-B1

Alphanumeric symbol in far left column corresponds to interface feature locations in Fig. A-1 – A-4.

N	FUEL OIL DRAIN PUMP DISCHARGE	57.86 CS 19.36 AFT 12.54 DWN	DN 25	FLANGE, TYPE B, RF TYPE 12, DN25 PN40, P245GH / PER EN 1092-1
P	LUBE OIL SUMP DRAIN	65.00 CS 51.17 FWD 1.07 DWN	DN 40	FLANGE, TYPE B, RF, TYPE 12 DN40 PN40 P245GH / PER EN 1092-1
Q	AFTERCOOLER DRAN LINE	65.00 CS 28.17 FWD 22.46 DWN	DN 25	FLANGE, DN25 PN40 / PER EN 1092-1 (NO PIPE ROUTING TO THE DUS BUILDING REQUIRED)
R	JACKET WATER DRAIN LINE	65.00 CS 77.97 FWD 23.53 DWN	DN 25	FLANGE, DN25 PN40 / PER EN 1092-1 (NO PIPE ROUTING TO THE DUS BUILDING REQUIRED)
S	JACKET WATER SURGE LINE	65.00 OCS 83.09 FWD 5.50 UP	DN 40	FLANGE, DN40 PN40 / PER EN 1092-1
T	AFTERCOOLER WATER SURGE LINE	65.00 OCS 40.91 FWD 23.71 UP	DN 40	FLANGE, DN40 PN40 / PER EN 1092-1
U	-	-	-	-
W	JACKET WATER VENT	37.83 OCS 19.50 FWD 72.39 UP	DN 25	FLANGE, DN25 PN40 / PER EN 1092-1
X	AFTERCOOLER VENT LINE	53.35 OCS 2.66 AFT 84.43 UP	DN 25	FLANGE, DN25 PN40 / PER EN 1092-1
Y	OIL REPLENISHMENT	22.60 CS 0.0 AFT 12.30 UP	DN 100	4 INCH A.N. (NPT) PIPE THREAD (NO PIPE ROUTING TO THE DUS BUILDING REQUIRED)
Z	FUEL OIL TANK DRAIN	63.55 CS 0.27 AFT 30.55 DWN	DN 15	FLANGE, DN15 PN40 / PER EN 1092-1
A1	FLUID WASTE LINE	48.95 OCS 126.23 AFT 41.38 DWN	A1 THROUGH A3 SHOULD BE CAPPED	
A2	FLUID WASTE LINE	48.95 OCS 47.07 AFT 41.38 DWN		
A3	FLUID WASTE LINE	48.95 OCS 30.19 FWD 41.38 DWN		
B1				

Table A-2

Electrical Interfaces AA-AI

Alphanumeric symbol in far left column corresponds to interface feature locations in Fig. A-1 – A-4.

SYMBOL	ELECTIRC JUNCTION BOX	FME SIDE OF TERMINAL STRIP
AA	AUXILIARY RTD	24X.406DIA + 24X.394DIA TOTAL AREA=6.02 INCHES^2
AB	ENGINE RTD UPPER	FME PULL BOX NOT A CUSTOMER CONNECTION
AC	ENGINE RTD LOWER	14X0.276 DIA. TOTAL AREA=0.83 INCHES^2
AD	K-TYPE THERMOCOUPLE	17X0.126DIA. TOTAL AREA=0.21INCHES^2
AE	LOOP POWER "4-20" MA TRANSMITTERS	FME PULL BOX NOT A CUSTOMER CONNECTION
AF	DISCRETE I/O	13X.394 DIA. TOTAL AREA=1.58INCHES^2
AG	GOVERNOR ACTUATOR	5X.394 DIA. TOTAL AREA=0.61INCHES^2
AH	VOLTAGE REGULATOR	4X.54 DIA. TOTAL AREA=0.91INCHES^2
AI	HIGH VOLTAGE	7X.54 DIA. TOTAL AREA=1.6INCHES^2

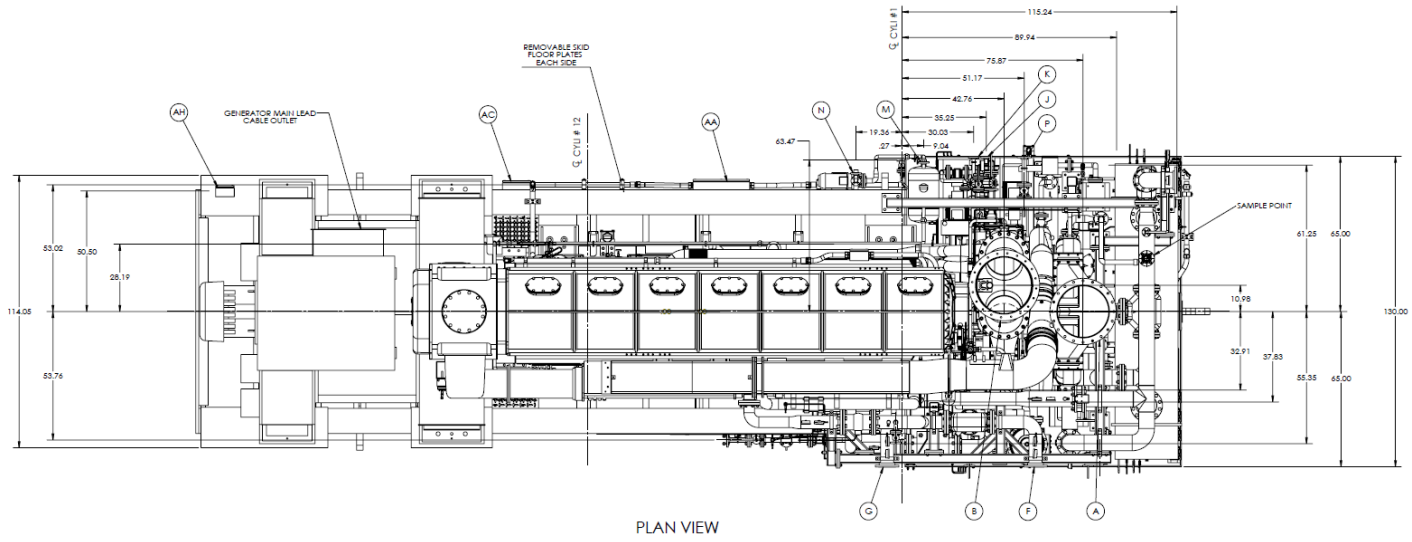
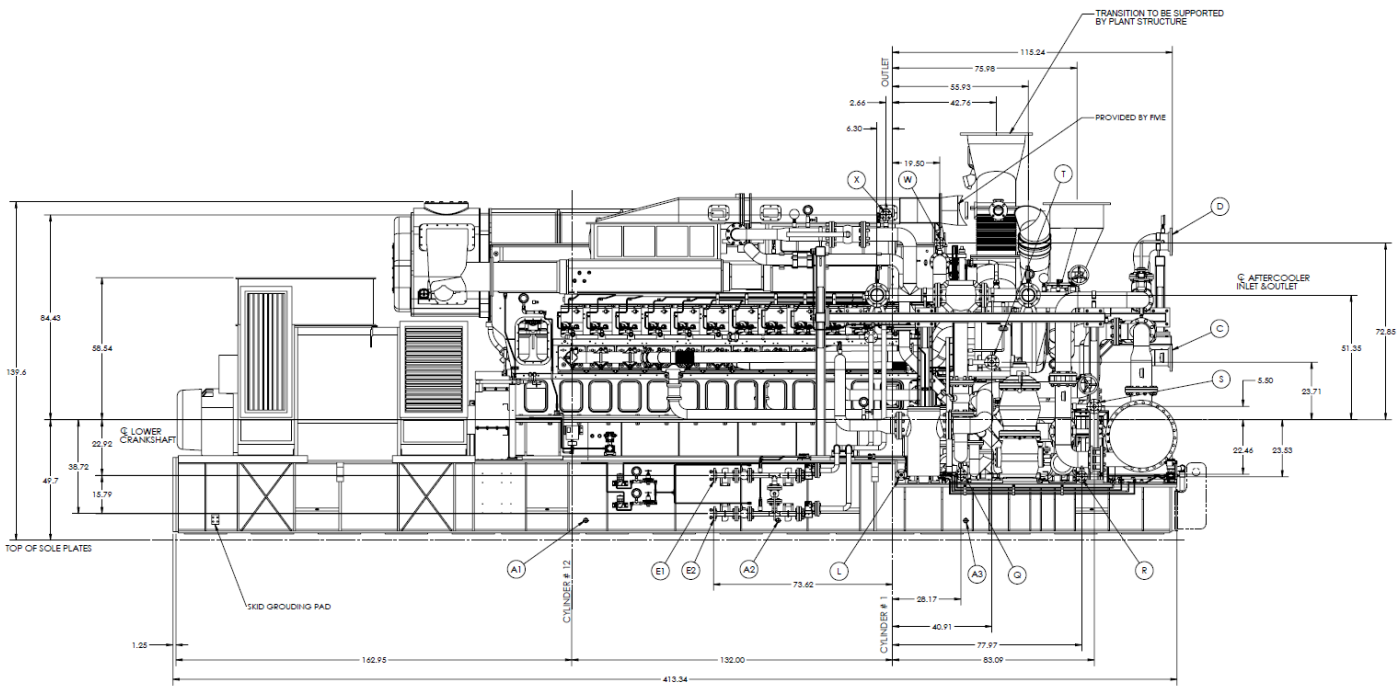


Fig. A-1

Plan (Aerial) View of Genset Showing Selected Fluid and Electrical Interface Points



OPPOSITE CONTROL SIDE VIEW

Fig. A-2

Opposite Control Side (Left) View of Genset Showing Selected Fluid and Electrical Interface Points

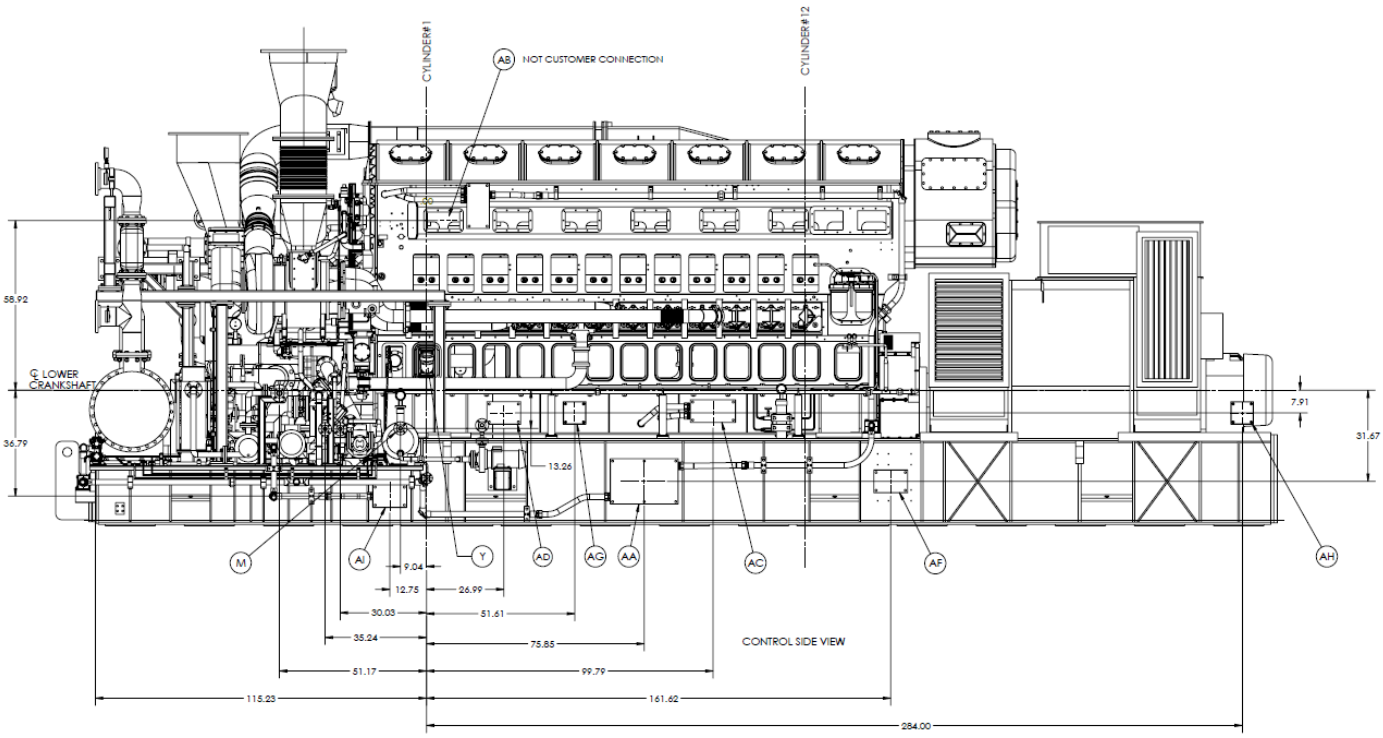


Fig. A-3

Control Side (Right) View of Genset Showing Selected Fluid and Electrical Interface Points

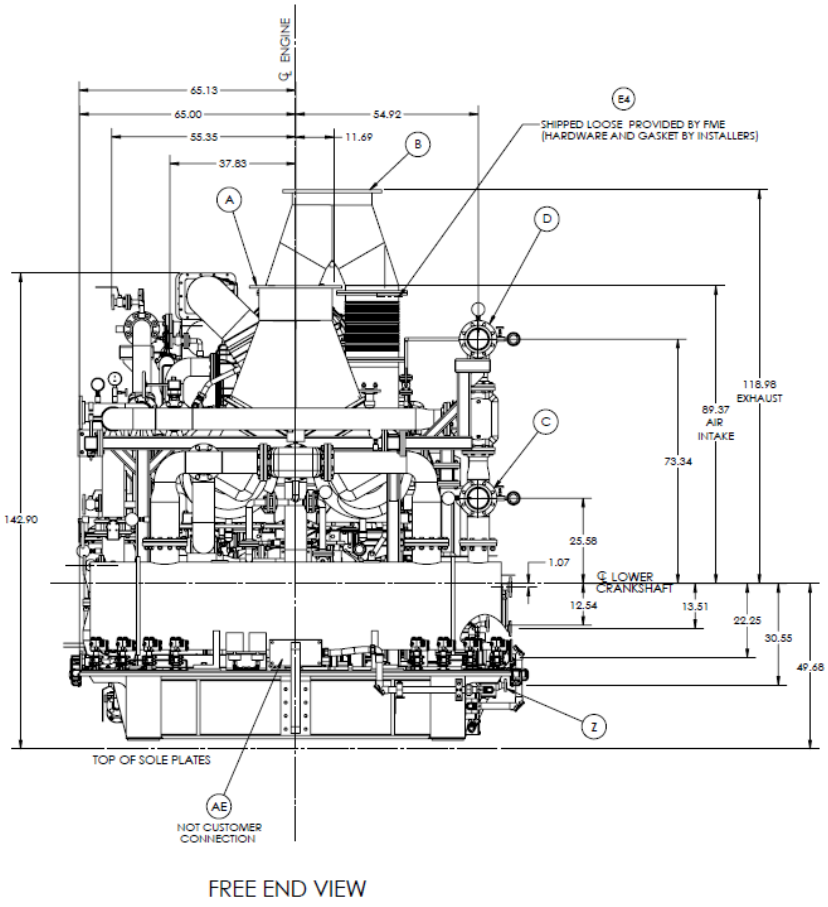


Fig. A-4

Free End (Rear) View of Genset Showing Selected Fluid and Electrical Interface Points

Appendix B

This appendix functions as a compendium of reference photos illustrating all points of interface between the model genset and the FME manufacturing and test facility in Beloit, Wisconsin, USA. Serial iterations of the DUS genset will have comparable points of interface. Any visible differences between the features represented in the following photos and the features of the genset as installed in the destination plant may be attributed to the installation of peripheral equipment ordered by a consortium member and not provided to FME during qualification testing of the model genset.

Fig. B-1
Turbocharger fresh air intake flange

Fig. B-2
Turbocharger exhaust flange

Fig. B-3.1
Jacket water pump suction flange (view 1)

Fig. B-3.2
Jacket water pump suction flange (view 2)

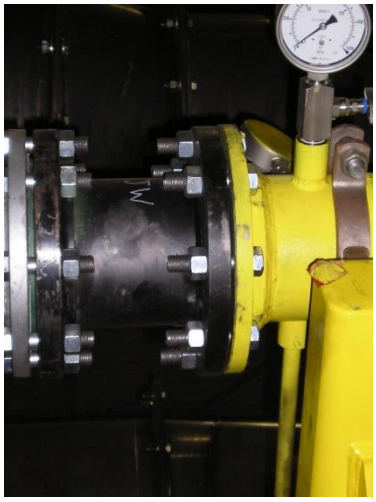


Fig. B-4
Jacket water pump discharge flange

Fig. B-5
Air start intake (upper and lower)

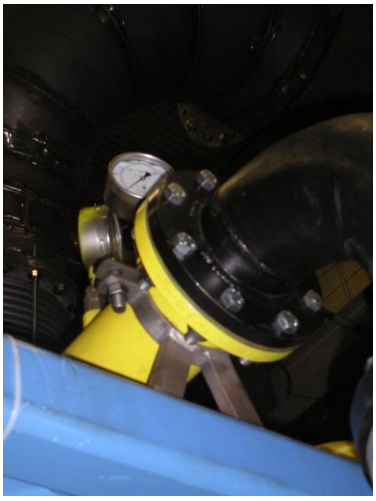


Fig. B-6
Intercooler pump suction flange

Fig. B-7
Intercooler water discharge flange

Fig. B-8
Fuel oil pump suction (left) and pump relief (right)

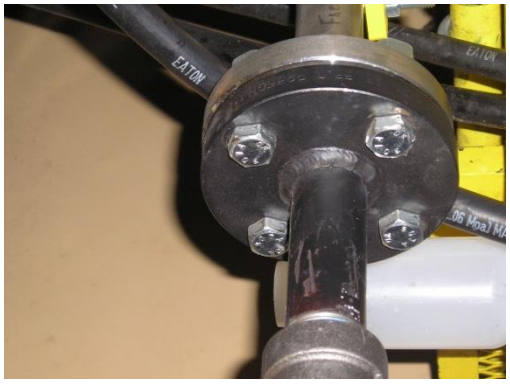


Fig. B-9
Fuel oil header return

Fig. B-10
Fuel oil drain tank overflow

Fig. B-11.1
Fuel oil tank drain pump discharge (view 1)

Fig. B-11.2
Fuel oil tank drain pump discharge (view 2)

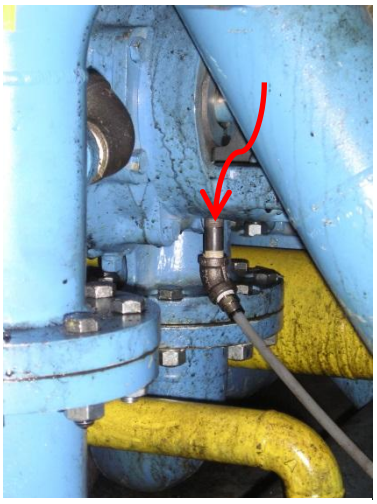


Fig. B-12
Lube oil sump drain

Fig. B-13
Aftercooler drain

Fig. B-14
Jacket water drain

Fig. B-15
Jacket water surge

Fig. B-16.1
Aftercooler water surge (view 1)

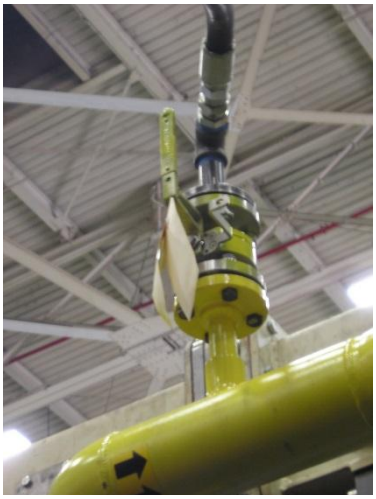


Fig. B-16.2
Aftercooler water surge (view 2)

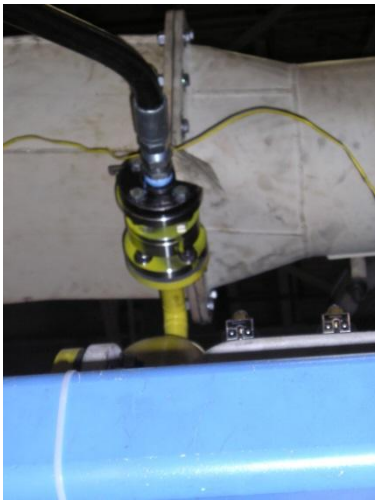


Fig. B-17
Jacket water vent

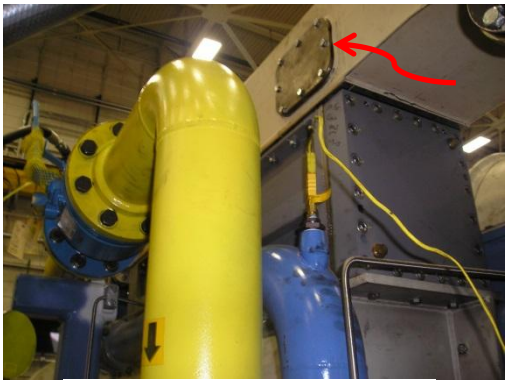


Fig. B-18.1
Aftercooler vent mounting point
(view 1 - vent not installed)

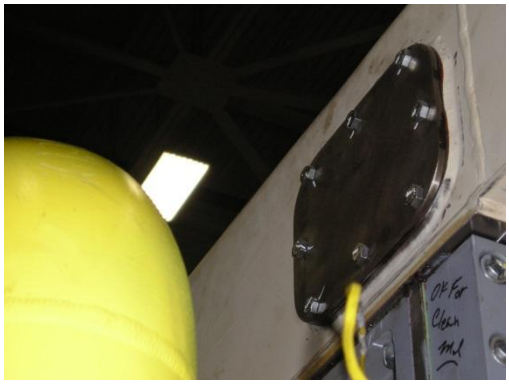


Fig. B-18.2
Aftercooler vent mounting point
(view 2 - vent not installed)

Fig. B-19
Lube oil replenishment intake

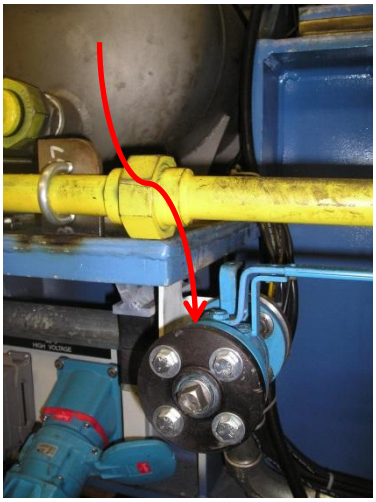


Fig. B-20
Fuel oil tank drain leak off (not installed)

Fig. B-21
Fluid waste line A1

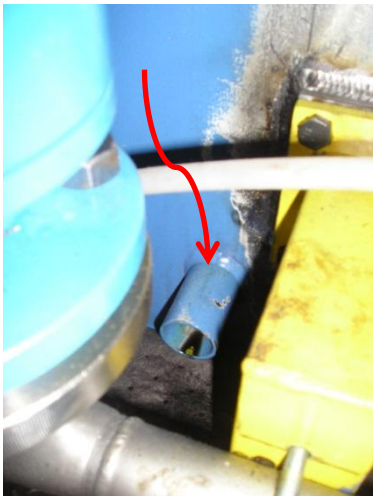


Fig. B-22
Fluid waste line A2

Fig. B-23
Fluid waste line A3

Fig. B-24
Engine RTD (upper) and auxiliary

Fig. B-25
Engine RTD (lower)

Fig. B-26
K-type thermocouple relay

Fig. B-27
Loop power 4-20 MA transmitters

Fig. B-28
Discrete input-output

Fig. B-29
Governor actuator

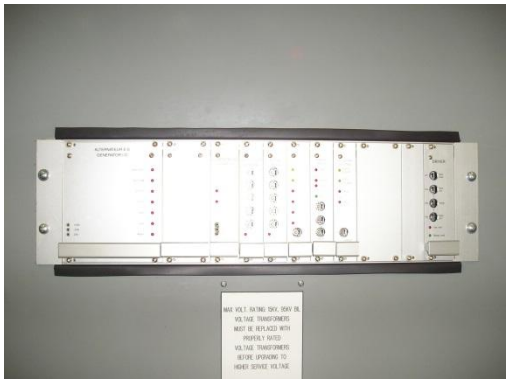


Fig. B-30
Voltage regulator

Fig. B-31
High voltage

Fig. B-32
Skid grounding strap

Fig. B-33
Alternator grounding strap