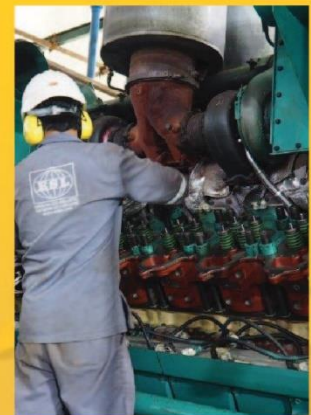




Energy Solutions (Pvt.) Limited

ENGINE OVERHAULS A CASE STUDY!



Engine Overhauls – A Case Study!

A customer owns two huge Textile Mills with almost identical machines. The Textile Mills are located one each in Karachi and Lahore. He uses 1 MW generators in both the Mills, which were bought almost at the same time few years back.

The customer complained about a problem which is quite common in the industry. The generators in the Karachi plant are more susceptible to maintenance and have undergone overhauls earlier than their counterparts in Lahore. He invited a team of power generation engineers to explain why it is so and what can be done to arrest premature failure of engines in Karachi than in Lahore.

The engineers informed the owners that overhaul of an engine is accelerated due to the following reasons:

1. Quality of installation
2. Environmental conditions
3. Maintenance practices
4. Operating conditions.



They carried out a root cause analysis of failure based upon the above factors and submitted the following findings:

The maintenance in Karachi plant has become due earlier than at Lahore because of a mix of the above factors. However, the Pareto Analysis clearly pointed towards training of engineers and operators which resulted in both improper maintenance practices and improper operating procedures. The following findings were more or less similar to those listed in any good literature on high horsepower engine overhaul:

1. Installation

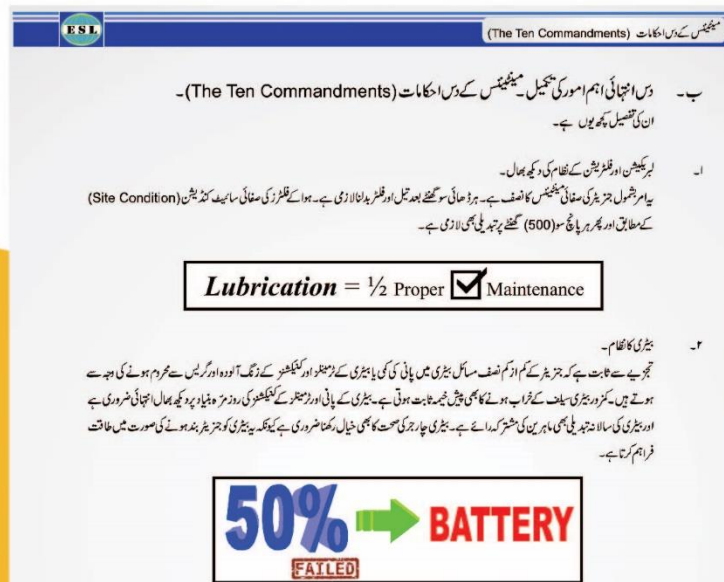
- It was found that engines were starved of fresh air as the openings were not of proper size at the Karachi plant.
- Possibility of exhaust fumes being routed back and getting mixed with fresh air for aspiration was also examined but not found.

2. Operators at both locations

- The operators at Karachi plant were not fully aware of:
 - the importance of daily maintenance
 - nor were they paying enough attention to the weekly list.
- Buildup of dirt, dust, mud was clearly visible.
- Damaged and dripping hoses were noticeable.

3. Fuel and lube oil quality

- Fuel & lube oil quality in both locations was of satisfactory nature and hence was not a factor.



ب۔ دس انتہائی اہم امور کی تکمیل۔ مینٹیننس کے دس احکامات (The Ten Commandments)۔
ان کی تعمیل کچھ یوں ہے۔

۱۔ لبریکیشن اور فیلٹریشن کے نظام کی دیکھ بھال۔
یہ امر مشمول ہر پریکٹس مینٹیننس کا نصف ہے۔ ہر ڈھائی سو گھنٹے بعد تیل اور فیلٹر بدلانا لازمی ہے۔ ہوا کے فلٹر کی مہلکی مانیف کونڈیشن (Site Condition) کے مطابق اور پھر ہر پانچ سو (500) گھنٹے پر تبدیل کرنا لازمی ہے۔

Lubrication = 1/2 Proper Maintenance

۲۔ بیٹری کا نظام۔
تجربے سے ثابت ہے کہ ہر پریکٹس کم از کم نصف مسائل بیٹری میں پائی گئی یا بیٹری کے سسٹم اور کنکشنز کے زچہ آلودہ اور گریس سے محروم ہونے کی وجہ سے ہوتے ہیں۔ کمزور بیٹری سیلف کے خراب ہونے کا بھی چٹاں نیم حقیقت ہوتی ہے۔ بیٹری کے پانی اور سسٹم کے کنکشنز کی روزمرہ دیکھ بھال انتہائی ضروری ہے اور بیٹری کی سلاخیں چھٹی ممبرین کی ہیشٹر کراہنے سے۔ بیٹری چار ہر پریکٹس کا بھی خیال رکھنا ضروری ہے کیونکہ یہ بیٹری کو ہر پریکٹس ہونے کی صورت میں طاقت فراہم کرتا ہے۔

50% BATTERY FAILED

4. Maintenance intervals

- Lube oil and filters were not changed as per manufacturer's recommendations at the Karachi plant.
- Oil change intervals were often extended beyond 250 hours
- Quality of filters also showed that focus was on replacing them without regard to quality.

5. Coolant specifications

- Severe liner pitting was observed at Karachi plant due to cavitation showing noncompliance with the quality and the concentration of the coolant.

6. Improper operating procedures

- Proper log books were not available nor maintained
- Sketchy information revealed that generators were operated at less than 40% load for extended periods of time in Karachi plant.
- It was also noticed that often engines were operated at 110% load for more than one hour in a period of twelve hours. This was clearly against engine rating guidelines which only permit 110% for only one hour in any period of twelve hours.
- Generators were often shut down without proper cooling run.
- Loads were also not balanced properly on the three phases and were not (even remotely) within 10% of each other.



According to all manufacturers severe operating conditions accelerate wear and call for shorter maintenance intervals which was not followed at the Karachi plant. The result was that the engine had to be prematurely overhauled.

The maintenance intervals for overhauls on most engines (except Quantum Series Engines) are as follows:

Table 1

Top Overhaul	Major Overhaul
6000 – 8000 hours or as per the conditions	14000 - 16000 hours or as per the conditions

The overhauls may be significantly delayed if good operation & maintenance practices are followed especially with regard to:



ایک مثالی اور ہال (A Perfect Overhaul)

ایک انجن کے ٹاپ اور ہال میں بنیادی طور پر اس کے ہیڈ اور اس سے منسلک پارٹس پر کام کیا جاتا ہے جن میں والوز، سٹیش، گائڈز، وغیرہ شامل ہیں۔ اس کا دورانیہ عام طور پر چھ ہزار گھنٹے اور اس کے لگ بھگ ہوتا ہے۔

ESL Customer Care Top Overhaul

- Check valve guides, replace if necessary
- Dismantle and clean turbo charger cooler
- Renew turbo charger bearing
- Inspect, service and calibrate injection pumps
- Decarbonizes piston and cylinders.
- Lift cylinder heads and reground (renew) valves and/or seal inserts
- Inspect crankcase interior for unusual condition, such as evidence of bearing metal
- Replace Water Pump, Auxiliary Cooling Pump and Coolant
- Replace cylinder heads with service exchange units.
- Clean and Test Aftercooler Assembly
- Replace the HT, LT and Lube Oil Thermostats.
- Replace Fuel (Gas) Filter
- Replace Fuel (Gas) Regulator
- Replace Fan and Alternator Belts




جب کہ میجر اور ہال میں ٹاپ اور ہال میں شامل کاموں کے علاوہ تمام بیئرنگز، لائنرز، گیس ککس، ٹریوچر جرز، واٹر پمپ اور دیگر پارٹس پر کام کیا جاتا ہے۔ اس کا دورانیہ یا عمومی بارہ ہزار گھنٹے ہوتا ہے۔

ESL Customer Care Major Overhaul

- In major overhauls, the engine is dismantled so as to allow all running parts to be cleaned, inspected for defect; and measured for wear.
- Schedule of wear and renewal limits are given in manufacture's workshop manuals.
- Where actual value exceeds the maximum advisable clearances stated, one or more components affecting the clearance should be replaced.
- Cooling spaces are checked for fouling and flushed-out to remove harmful deposits.
- Joints, seals and connections are renewed if they have been disturbed.
- All engine instruments are calibrated




1. Proper training of on-site operator / technician / engineer.
2. Daily maintenance by the operator including the cleanliness of the plant equipment and the plant room.
3. Weekly maintenance by the operator.
4. Oil & Filters change religiously at 250 hours interval (when using standard oil available in market) by authorized technician.
5. Allowing only clean / cool air for aspiration through air filters, which must be changed every 1000 hours.
6. Proper care of engine cooling system using proper coolant.
7. Maintaining average load of 70%.
8. Maintaining balance between loads at the three phases within 10% of each other.
9. Allowing a cooling run of 5 – 10 minutes (depending on size of the genset) when shutting down the engines.
10. Regular oil sampling.

The need for overhaul is expressed through the following conditions:

Table 2

01	Increased oil consumption
02	Increased fuel consumption
03	Increased blow by
04	Presence of wear metal particles in oil analysis
05	Exhaust smoke color changes to black, blue or white
06	Increased engine vibration
07	Increased noise

The activities required in various overhauls are as under:

Table 3

		Top Overhaul	Major Overhaul
01	Oil Suction Screen	Clean	
02	After Cooler Core	Inspect, clean, pressure test	
03	Fuel System Leakages	Inspect	
04	Connecting Rod Bearings	N/A	Inspect & Replace
05	Cylinder Liners	N/A	Replace
06	Pistons (Crown & Skirts)	N/A	Inspect & Replace depending on the condition
07	Piston Pins	N/A	Inspect & Replace depending on the condition
08	Piston Rings	N/A	Replace
09	Rocker Arms	Inspect, Rebuild	
10	Cylinder Head Assemblies with Valves, Guides, Inserts & Springs	Rebuild or Replace	
11	Fuel Priming Pump	N/A	Replace

		Top Overhaul	Major Overhaul
12	Engine Oil Pump	N/A	Inspect or Replace
13	Fuel Injection Pump	Inspect, Rebuild & Calibrate or Replace	
14	Camshaft Followers	N/A	Inspect, Replace
15	Engine Wiring Harness	Inspect, Replace	
16	Push Rods	Inspect & Replace	
17	Turbochargers	Rebuild or Replace	
18	Fuel Injectors	Rebuild & Calibrate or Replace	
19	Gaskets and Seals for the Air Intake Manifold	Replace	
20	Flexible Bellows and Seals for Exhaust Manifold	Replace	
21	Camshafts	N/A	Inspect
22	Cylinder Blocks	N/A	Replace
23	Cranks shaft Vibration Damper	N/A	Inspect
24	Flywheel	N/A	Replace
25	Front Gear Train	N/A	Inspect
26	Rear Gear Train	N/A	Replace
27	Connecting Rods	N/A	Inspect, Rebuild or Replace
28	Oil Cooler Core	N/A	Inspect, Rebuild or Replace
29	Camshaft Thrust Washers	N/A	Inspect, Replace
30	Crankshaft	N/A	Inspect, Replace
31	Engine Mounts	N/A	Inspect, Replace
32	Camshaft Bushes /Bearings	N/A	Replace
33	Crankshaft Seals	N/A	Replace
34	Crankshaft Thrust Plates	N/A	Replace
35	Gear Train Bushings	N/A	Replace
36	Main Bearings	N/A	Replace
	Miscellaneous items: Radiators, Starting Motors, Battery Charger (Dynamo), Water Pumps, Switch Gears & Breakers, Control Panel, ATS Panel, Sound Attenuation Containers	Inspect, Clean, Repair or Replace as per the conditions	

Load Testing of Generators after Overhaul:

Load testing is an important part of proving the capability of generating sets at the time of manufacture, commissioning and later in the life of the set e.g after an Overhaul. Load banks are widely used for load testing.

There are, generally, three performance classes - G1, G2 and G3 of generators, which are as follows:

<i>Performance Class</i>	<i>G1</i>	<i>G2</i>	<i>G3</i>
Steady-state frequency band	2.5%	1.5%	0.5%
Maximum frequency dip	-15%	-10%	-7%
Maximum frequency rise	+18%	+12%	+10%
Frequency recovery time	10 seconds	5 seconds	3 seconds
Steady state voltage deviation	5%	2.5%	1%
Maximum voltage dip	-25%	-20%	-15%
Maximum voltage rise	+35%	+25%	+20%
Voltage recovery time	10 seconds	6 seconds	4 seconds

In practice, almost all generating sets witness a non-unity power factor load when in normal use. The question now is what kind of load bank be used for the load test after an overhaul.

Most generating sets are designed and specified at a power factor of 0.8, and the engine is therefore not capable of delivering full kVA at unity power factor. For example a 1000kVA genset rated at 0.8 power factor, would only be able to deliver 800kW into a purely resistive load. Testing using a resistive load will usually result in full load test of the prime mover (i.e. the engine), but not of the alternator, which will be tested only to the extent of 80% of its rated current. The result of all this is that the alternator would run significantly cooler. This is both because the current is lower and exactly in phase with the voltage (i.e. unity power factor). So the thermal performance of the generating set as a whole will not be tested as it would be if the rated, non-unity power factor load were applied.

پاور فیکٹر (Power Factor)۔ ایک معمہ سمجھنے کا، نہ سمجھانے کا۔۔۔

برسلو شہر کے وسط میں ایک شراب خانہ واقع ہے جہاں نہایت عمدہ قسم کی شراب خاص مہمانوں کو پیش کی جاتی ہے۔ شراب کا ایک گلاس تقریباً سو ڈالر میں دستیاب ہوتا ہے۔ ہر گلاس میں تقریباً اسی فیصد شراب ہوتی ہے اور بیس فیصد اسکا جھاگ۔ یعنی گلاس میں اسی ڈالر شراب کے لئے ادا کرتا ہے اور بیس ڈالر جھاگ اس جھاگ کے لئے جو اسے کسی کام کا نہیں۔ پھر اچانک برسلو کی انتظامیہ یہ فیصلہ کرتی ہے کہ گلاس کو اتنے ہی پیسے ادا کرنے ہوں گے جتنی وہ شراب نوشی کرتا ہے۔ یعنی اب اسکو جھاگ کے پیسے ادا کرنے کی قطعی ضرورت نہیں۔ اس فیصلے سے شراب خانے کا کاروبار بڑی طرح متاثر ہوتا ہے اور وہ ایک منافع بخش ادارے سے تبدیل ہو کر غیر منافع بخش ادارہ بن جاتا ہے۔



کچھ اسی طرح کی صورتحال کا سامنا بجلی فراہم کرنے والی کمپنی کو بھی کرنا پڑتا ہے۔ وہ بجلی کا ایک گلاس صارف کو فراہم کرتی ہے اور صارف اس میں سے فقط 70 تا 80 فیصد کا آمد استعمال کے لیے خرچ کرتا ہے۔ باقی 20 تا 30 فیصد بجلی جھاگ کی طرح دھری کی دھری رہ جاتی ہے۔ بجلی فراہم کرنے والی کمپنی مثال کے طور پر ایک لاکھ روپے کی بجلی فراہم کرتی ہے اور صارف اس کے صرف 70 تا 80 ہزار روپے ادا کرتا ہے۔ جانتے ہیں ایسا کیوں ہے؟ ایسا پاور فیکٹر کی بدولت ہے۔۔۔!

Many engineers who test generating sets consider that this is not very important, since usually the alternator is of proven design. There is no doubt that resistive-only tests do give valuable and useful data, but they do not portray the whole picture.

The dangerous thing, however, is that a newly manufactured or overhauled engine is tested by applying the full kVA rating to the alternator. This means that a unity power factor load of 1000 kVA at alternator would result in 1000 kW on the engine, which would be 25% higher than its rated capacity and hence a recipe of disaster for the new or recently overhauled prime mover.

Furthermore, the tendency is now growing worldwide to test the generators at manufacturing stage and after major services like overhauls at non unity power factors, so that the entire genset along with its engine, alternator, ancillary components such as breakers, connections, wirings, meters and instrumentation are fully tested to their limits

However, please be careful with capacitive load banks. There is a risk that leading power factor loads could result in the AVR of a generating set losing control of the output voltage, since the inductive windings of the alternator will interact with the capacitive load to generate power even if there is no excitation at all from the control system.

The load provided by capacitive load banks simulate electronic or non-linear loads typical of telecommunications, computer or UPS (Un-interruptible Power Supply) industry. These can incorporate numerous switched mode power supplies that introduce large amounts of distortion and harmonics due to the electronic switching of the waveform.

Condition based Overhaul / Maintenance:

There is a growing trend to perform overhaul based upon condition. There is no harm in it. However, it requires listening to the voice of the parts

Do the generator parts talk!

Yes! The parts in a machine also talk. All they need is an engineer who can listen to their voice and decode the message they send out.



The appearance of parts and their physical properties only can tell us a little bit about them. Once they are put in the machine following a breakdown or an act of preventive maintenance or during an overhaul, they come into their own. They start talking. Whether they are good or not; genuine or fake becomes evident through their own conduct or their interaction with the other parts in the same machine. Yes, the parts start talking!

If they are good and genuine, they adjust themselves well with the rest of the machine and the machine finds comfort in their company and reaches optimum performance. On the contrary, if they are second grade, they start misbehaving. They start hurting others and hurting themselves too in the process. The overall outcome is that the whole machine starts to suffer. The performance of the machine drops down and the machine starts falling sick at regular intervals and ultimately refuses to work.



The non-genuine parts not only fail themselves but result in consequential failure of other parts too, sometimes vital and much more expensive ones. The result is premature failure of the machine and more importantly stoppage of the whole production line, wasted hours of the work force, uncalled for delays in supplying customer orders, lost orders, lost customers and lost business. Therefore, what started as an apparently harmless exercise of saving a little money in the procurement of parts turns out into a tragedy.

Just as a good salesperson listens to the voice of the customer, a good engineer or a technician always tries to listen to the voice of the parts. As they work (run), they need cleaning, lubrication, health examination etc. Lack of attention starts to show on the voice of parts. They start to squeak, screech and scream. A good engineer listens to these changes in the voice. He does not let these changes happen in the first place but in case the signs show up he takes immediate corrective actions until their voice becomes normal again.

Listen to the voice of the parts in a generator also

- In case of a generator, an engineer must keep talking to the parts and listen to their voice. He may notice unusual vibrations, an abnormal sound, a change in color of the engine exhaust, increased lube oil consumption, higher fuel consumption, low oil pressures, high oil and coolant temperatures, traces of metal in the lube oil, excessive blow by, etc. These are all symptoms and ways parts express themselves.
- The golden rule is to replace old parts with genuine parts only, provide machine regular cleaning and lubrication, change filters regularly, ensure handling by authorized professionals only and continually listen to the voice of the parts just as doctor listens to his patient and looks for changes. The parts will outlast and outlive your expectations. They will do even better than the manufacturer recommendations.
- Listen to the voice of the parts and change them only if they warrant a change. There is no need for premature changes. This is called condition-based maintenance. Be assured your generator will last 15,000 - 20,000 hours or more before a major surgery (overhaul), and will then again be ready to go for a similar length of time.

OEM vs After Market Parts:

The generator market is full of OE and aftermarket parts. When you go to the distributor's service department for repairs, you know you're getting Original Equipment Manufacturer (OEM) parts. However, if you take recourse to a non-distributor, you'll most likely get aftermarket parts. Is there anything wrong with that? Does a less expensive part mean a poorer-quality part? And in what situations should you use only OEM parts?

Let's see a comparison of both OEM & Aftermarket parts:

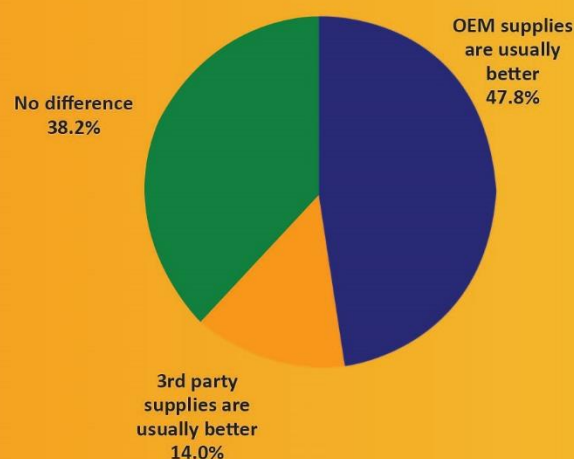
Table 4

S.No	Criterion	OEM Parts	Aftermarket Parts	Remarks
1	Cost	Nearly 50 – 60% more expensive	Less expensive than OEM parts because of very large scale production / economies of scale.	A very large number of OEM parts come from the same source as aftermarket parts with OEM branding e.g Bosch produces parts for OEM as well as aftermarket; FP produces parts for OEM as well as aftermarket for cars, trucks, generators etc. However, it is always best to stay with OEM parts as they offer peace of mind and best value for money.
2	Quality	The OEM part should work exactly as the one you are replacing.	Quality can be less than or equal to OEM parts depending on where you buy from	Quality of aftermarket parts can be questionable especially because they are available from numerous suppliers who may not be quality conscious and prefer to mix and match for greater financial benefits. In rare cases, you may end up with a better part than you started with. "The aftermarket companies reverseengineer the part, and work the weaknesses out".

S.No	Criterion	OEM Parts	Aftermarket Parts	Remarks
3	Variety	You get only one type which is the same as originally provided	More variety is available with varying prices; though some companies specialize in specific parts	Variety of aftermarket parts may lead to confusion and headaches. Therefore, it is better to stick with OE parts.
4	Availability	Available mainly with the distributor or its dealer often with extended lead times	Readily available throughout the nook and corner of the country at 80% of the shops.	Large scale business of aftermarket parts often makes it difficult to control prices as well as quality, as copycat versions also become available. To save yourself from copycat versions, it is better to stay with OE parts.
5	Ease of selection	Straightforward selection with respect to parts numbers	Difficult to choose from a variety of options	If you're not familiar with aftermarket brands, the selection could be overwhelming, and there's a lot of chance you may get a bad quality part.
6	Warranty	Come with warranty of one year	May not have warranty	To keep costs down, aftermarket parts are often sold without a warranty.

Which Is the Best Way To Go?

All aftermarket parts are not created equal — but all OEM parts are. If you're not familiar with aftermarket brands, prefer to have everything done at the dealership and don't mind paying a bit extra for that peace of mind, OEM parts is always a very good choice for you.



ESL House, DP-01, Sector-21,
Korangi Industrial Area,
Karachi, Pakistan.
+92-301-8215873
+92-21-111-222-ESL (375)
+92-21-35019496

ESL House, Plot No. 431-D,
Kamaha Aashiana Road (Rohi Drain),
Off Ferozpure Road, Lahore, Pakistan.
+92-42-111-222-ESL (375)
+92-300-8443016; +92-302-8487965
+92-42-35923260

ESL House, Plot No. 82,
Street No. 10, Industrial Area I-9/2,
Islamabad, Pakistan.
+92-51-111-222-ESL (375)
+92-300-5219855
+92-51-4433177