



R2301-01GC
Delphi Automotive Systems

Preface

The following report details the compressed air audit conducted at Delphi Diesel Systems Limited, Sudbury from 11.44am on the 9th of March through to 13.23 on the 20th of March 2001 (265.7 hours).

The installation of calibrated auditing equipment to facilitate data logging via an industrial PC at a log rate of 5 seconds per channel provided raw data to an analysis software package. Within this software package, the raw data was configured against the known power and output performance for each air compressor and the cost of energy on site over a 24-hour cycle.

Through this audit we are able to establish existing system performance, identifying opportunities where significant improvements into system efficiency can be effected.

Site Data

Company: Delphi Diesel Systems Limited
 Address: Newton Road
 Sudbury
 Suffolk
 CO10 2RR
 England

Contact: Mr P. W. Vallance – Central Services Manager

Equipment audited: Compressor 1 – HPC (Kaeser) FS440
 Compressor 2 – HPC (Kaeser) DS170
 Compressor 3 – HPC (Kaeser) DS170
 Compressor 4 – HPC (Kaeser) DS170
 Compressor 5 – HPC (Kaeser) FS440
 Compressor 6 – HPC (Kaeser) FS440

Compressor reference data:

<u>DS170</u>		<u>FS440</u>	
Output	583 cfm (16.5m ³ /min)	Output	1628 cfm (46.1m ³ /min)
Pressure	7.5 bar g	Pressure	7.5 bar g
T.P.I.P.	98.75kW (fully loaded)	T.P.I.P.	267kW (fully loaded)

Site electrical cost data:

Weekdays:

00:00 – 07:00 £0.01414kWhour
 07:00 – 24:00 £0.04095kWhour (November – March)
 07:00 – 24:00 £0.02457kWhour (April – October)

Weekends:

00:00 – 24:00 £0.01703kWhour (January – December)

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Site statistical review

<u>Topic</u>	<u>Running</u>	<u>Loaded</u>	<u>Unloaded</u>
Compressor 1	1.37%	17.93%	82.07%
Compressor 2	67.05%	57.27%	42.73%
Compressor 3	66.40%	60.79%	39.21%
Compressor 4	63.43%	69.71%	30.29%
Compressor 5	2.76%	75.28%	24.72%
Compressor 6	84.70%	85.54%	14.46%

In order to satisfy demand, Compressor 6 (1 x FS440) has been used to meet base load demand with Compressors 2, 3 & 4 evenly utilised to meet the changing demand for compressed air on site (see Figure 1).

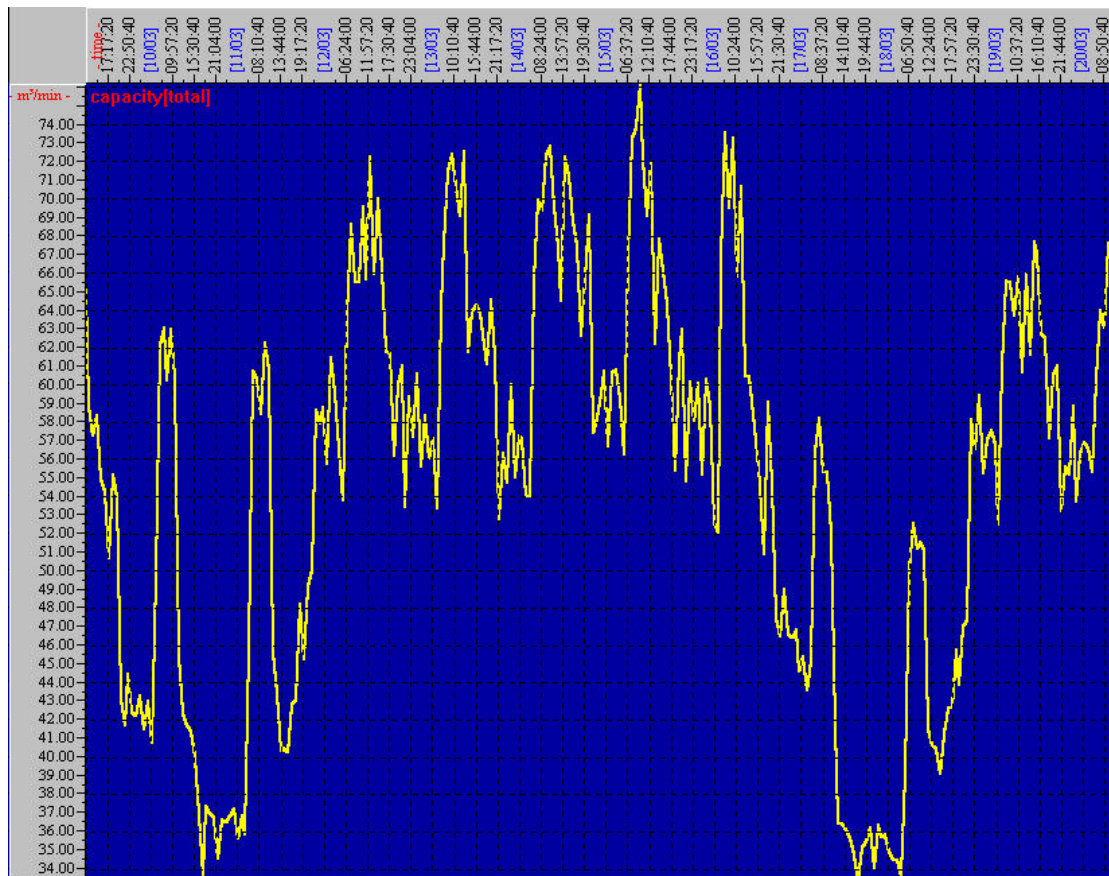


Figure 1

Base demand for compressed air was measured at 34m³/min requiring 1 x FS440 and 1 X DS170 compressor to operate. 2 x DS170 compressors were used to meet changes in air consumption with a peak-measured demand of 74m³/min. 2 x FS440 compressors were rarely operated during our audit.

<u>Topic</u>	<u>Total</u>
Input	94039.75kW hours
Output	875737.06 m ³
Operational time	265.7 hours
Productive input (energy)	85.15%
Non-productive input (energy)	14.85%
Efficiency	6.44kW/m ³ /min
Cost efficiency	£0.0036/m ³
Total cost of energy (logged period)	£3,160.01

System performance review

Compressor utilisation

Of the total energy consumed by each compressor, 14.85% of this energy was ‘non-productive’. That is, compressors were rotating but not compressing air.

An extract from a current data file (Figure 2) shows the effect of compressors rotating but not compressing air. Here as with all 6 compressors in your system, the compressor loads as a result of decay in pressure. Loading at the beginning of the green (productive) area, building up to pressure at the green area peak and off loading where current begins to fall (yellow – non productive energy). When decay in pressure is detected once more, the compressor loads again.

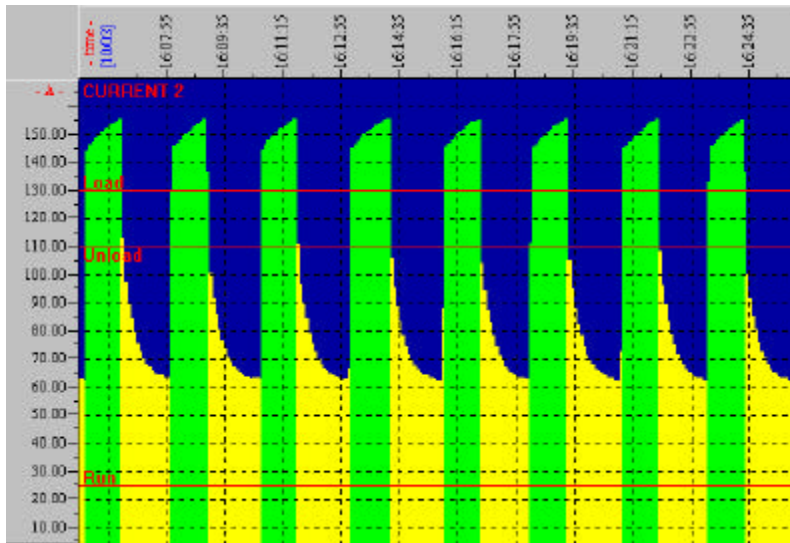
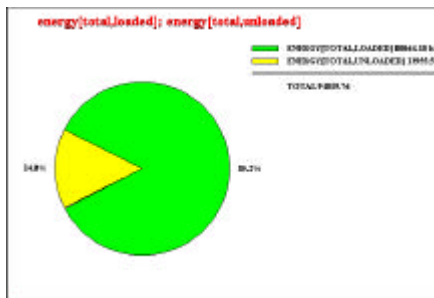


Figure 2

By isolating loaded or productive energy from energy that is unloaded or non-productive, the system can be reviewed as follows:



Non-productive energy represents 14.8% of all energy used.



Non-productive energy represents 14.6% of energy costs, which is a result of changing energy tariffs across the 24-hour cycle.

If we take the total cost of energy over the audit (265.7 hours) which was £3,160.01 and annualise this:

Cost of energy £3,160.01 in 265.7 hours or £104,184.00 per annum

Of which productive & non-productive energy represents:

Productive £2,698.64 in 265.7 hours or £88,973.64 per annum

Non-productive £461.36 in 265.7 hours or £15,210.86 per annum

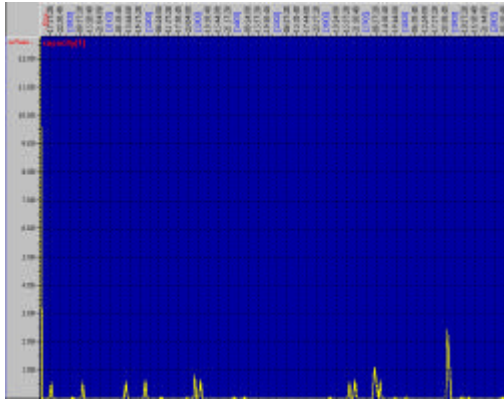
Compressor performance data during audit period

Compressor 1: HPC (Kaeser) FS440

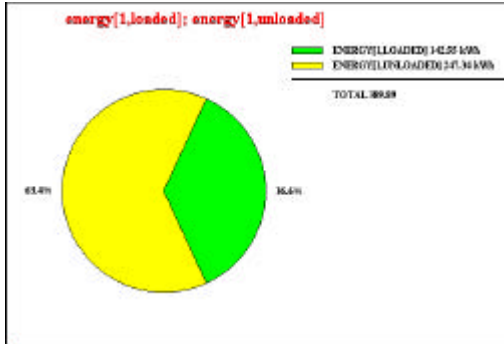
Notes:

Hour meter readings at start of audit:

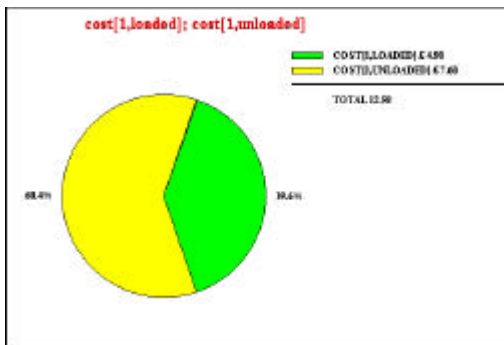
18,547 hours total
14,666 hours loaded



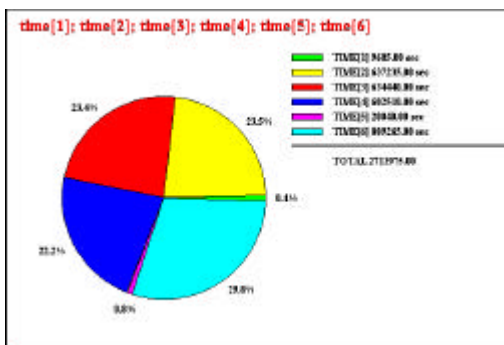
Compressed air output.



Productive / non-productive energy used.



Cost of productive / non-productive energy used.



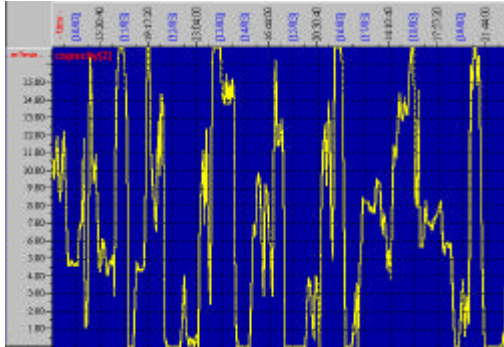
Compressor utilisation as a time percentage of all compressors utilised.

Compressor 2: HPC (Kaeser) DS170

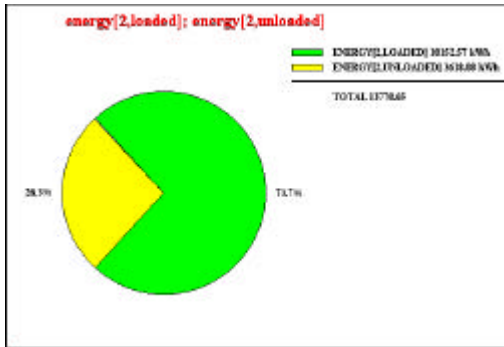
Notes:

Hour meter readings at start of audit:

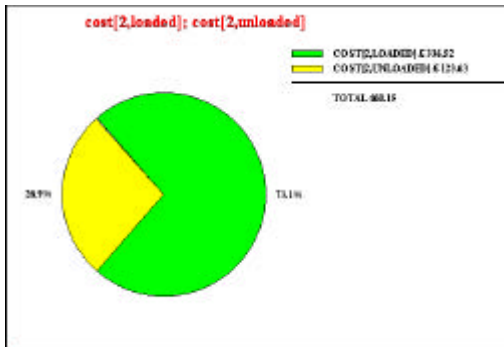
24,483 hours total
16,115 hours loaded



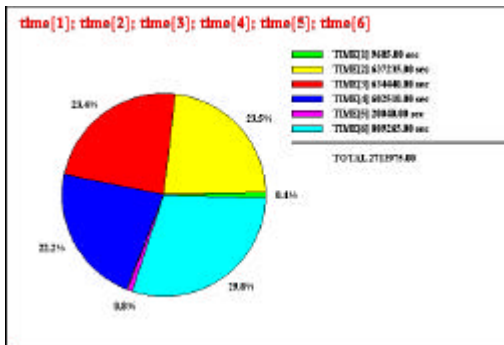
Compressed air output.



Productive / non-productive energy used.



Cost of productive / non-productive energy used.



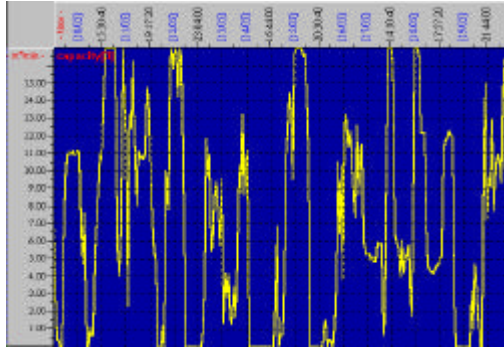
Compressor utilisation as a time percentage of all compressors utilised.

Compressor 3: HPC (Kaeser) DS170

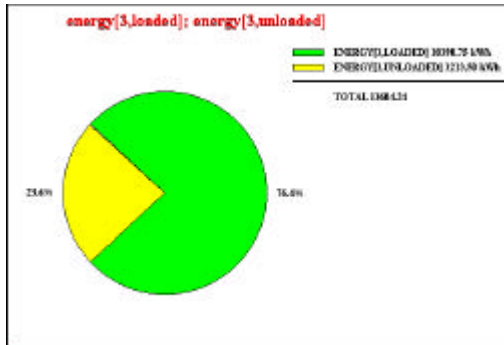
Notes:

Hour meter readings at start of audit:

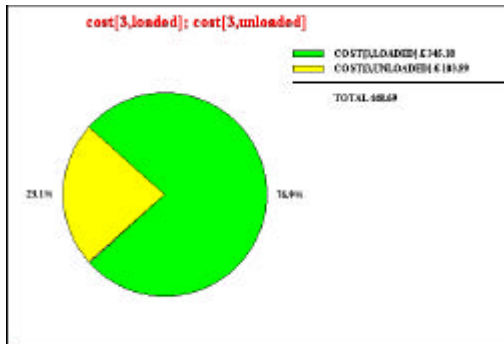
24,490 hours total
16,021 hours loaded



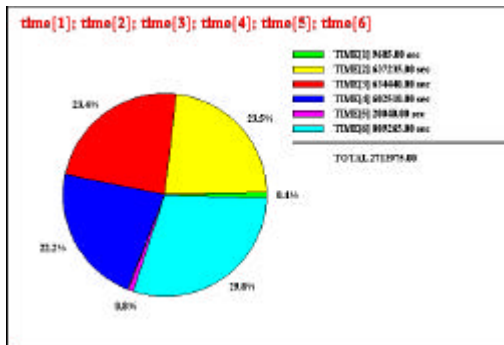
Compressed air output.



Productive / non-productive energy used.



Cost of productive / non-productive energy used.



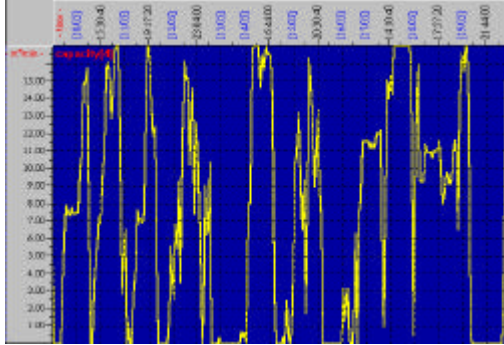
Compressor utilisation as a time percentage of all compressors utilised.

Compressor 4: HPC (Kaeser) DS170

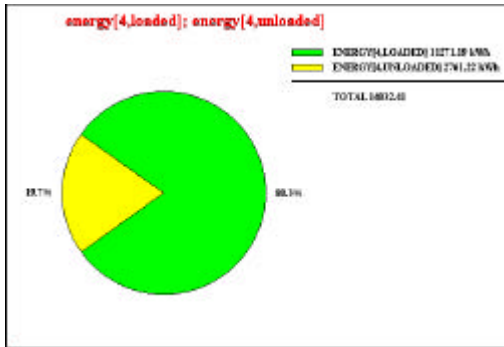
Notes:

Hour meter readings at start of audit:

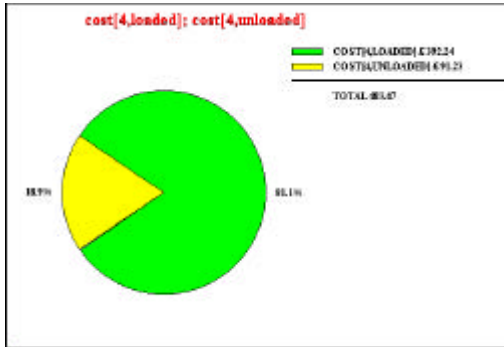
11,194 (new clock installed – data assumed to be consistent with 2 & 3) hours total
 16,518 hours loaded



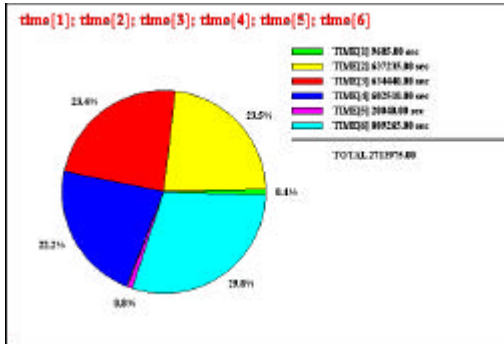
Compressed air output.



Productive / non-productive energy used.



Cost of productive / non-productive energy used.



Compressor utilisation as a time percentage of all compressors utilised.

Compressor 5: HPC (Kaeser) FS440

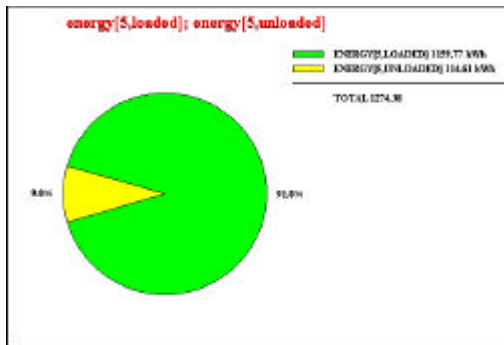
Notes:

Hour meter readings at start of audit:

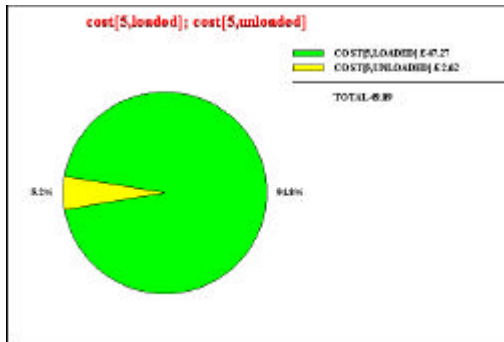
18,203 hours total
15,203 hours loaded



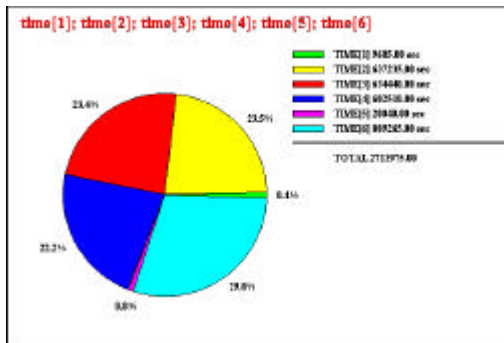
Compressed air output.



Productive / non-productive energy used.



Cost of productive / non-productive energy used.



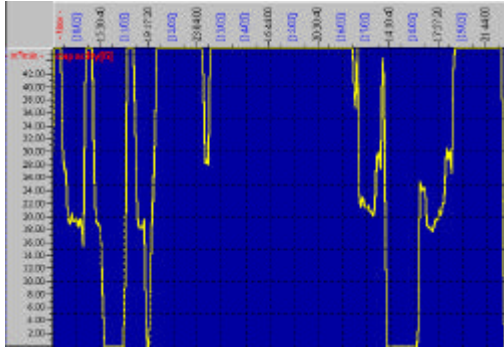
Compressor utilisation as a time percentage of all compressors utilised.

Compressor 6: HPC (Kaeser) FS4400

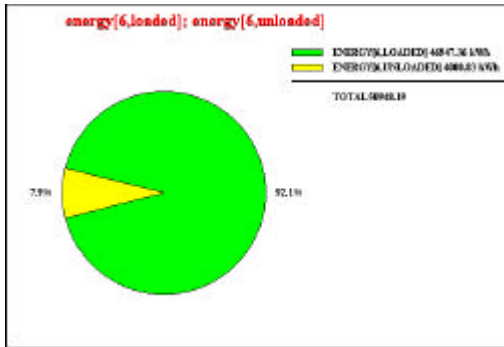
Notes:

Hour meter readings at start of audit:

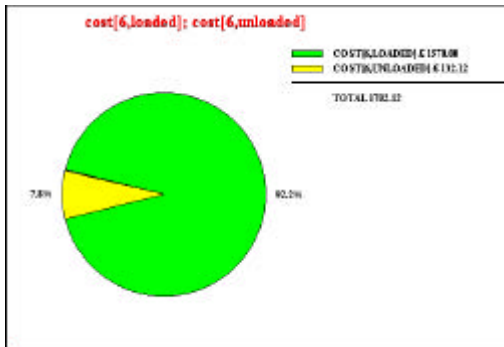
12,857 hours total
10,230 hours loaded



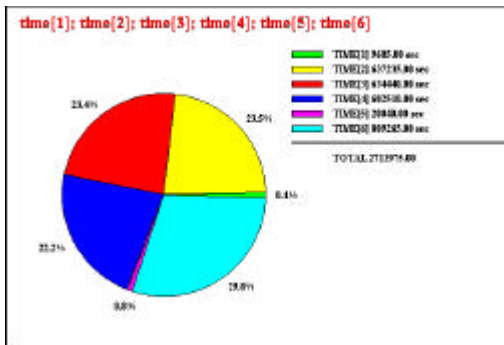
Compressed air output.



Productive / non-productive energy used.

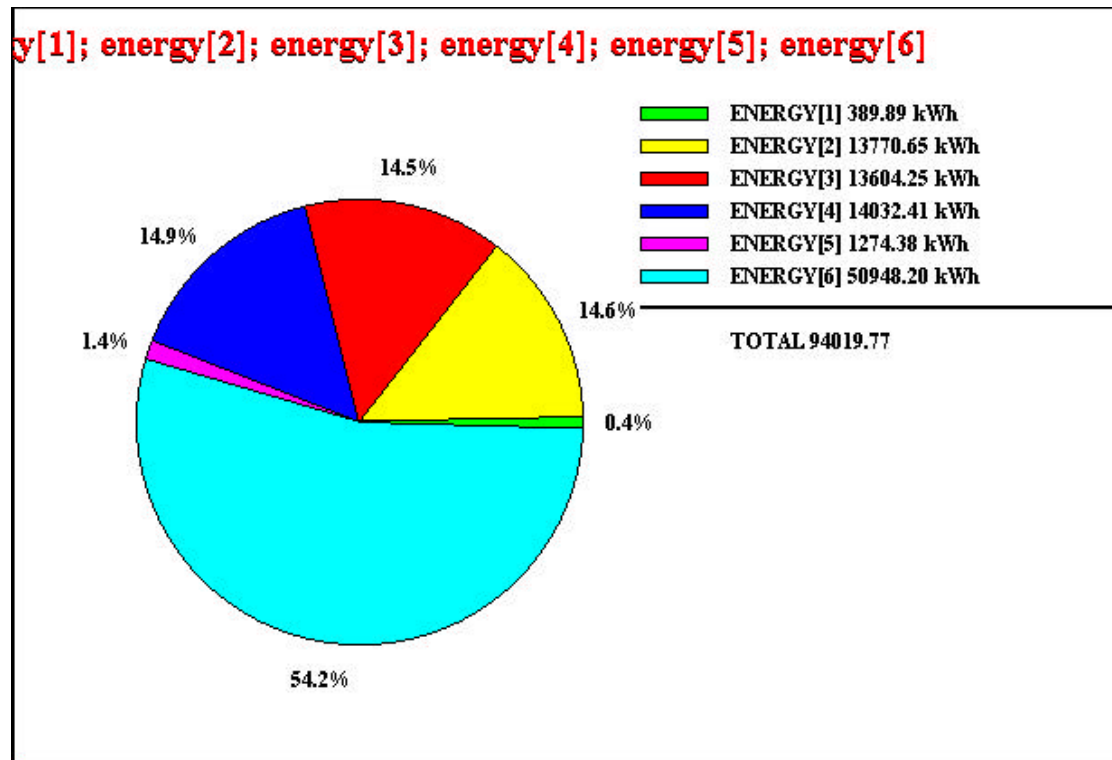


Cost of productive / non-productive energy used.

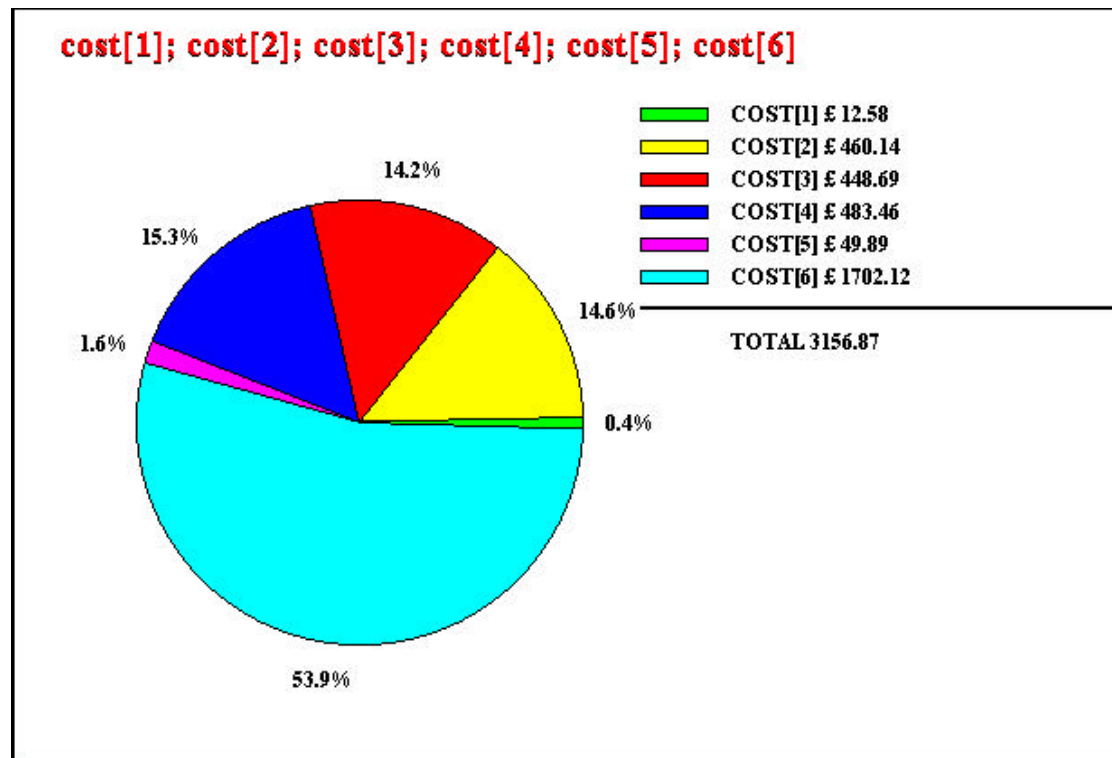


Compressor utilisation as a time percentage of all compressors utilised.

Compressor energy analysis as an energy percentage of total energy used.



Compressor energy cost analysis as an energy cost percentage of total energy cost.



Conclusions & Recommendations

From the audit conducted, it can be seen that Compressor number 6 (HPC (Kaeser) FS440) was used to satisfy base load demand and that a combination of compressors 2,3 & 4 (HPC (Kaeser) DS170) compressors were used to satisfy changing demands for compressed air over the audit period.

It is assumed that compressor number 6 is being used as the base load compressor in an effort to even utilisation among compressors 1, 5 & 6 and that even utilisation of these compressors would become norm.

All compressors are loaded & unloaded by an MVS8000 (PLC) control panel, taking a control pressure from a 4-20mA pressure transmitter. Sequencing of compressors is then managed by the MVS8000.

No efficiency data is recorded by the MVS8000.

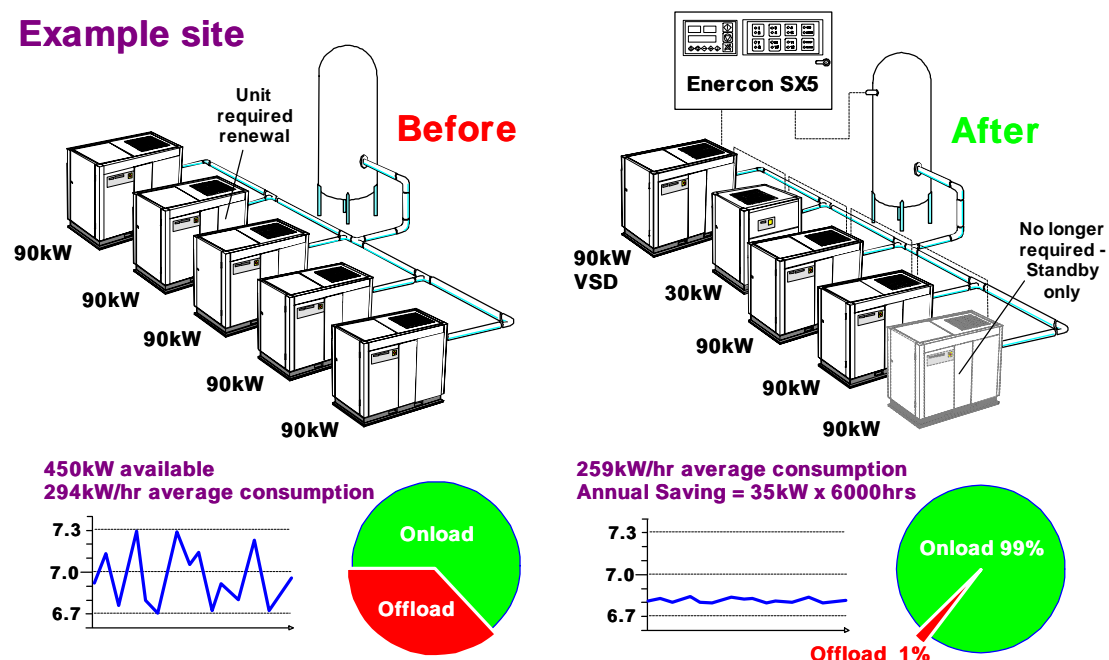
Recommendation 1

In order to more closely match compressed air generated to that of the air demand profile audited, compressor 2, 3 or 4 should be converted to variable speed drive.

By converting compressor 2, 3 or 4 to variable speed drive and used in a coherent way with existing fixed speed compressors, a major reduction in off load energy will result.

The variable speed compressor would be used to efficiency modulate between the air demands of less than one full compressor. Managed along with fixed speed compressors, this will reduce off load energy consumption (14.8% of all energy consumed).

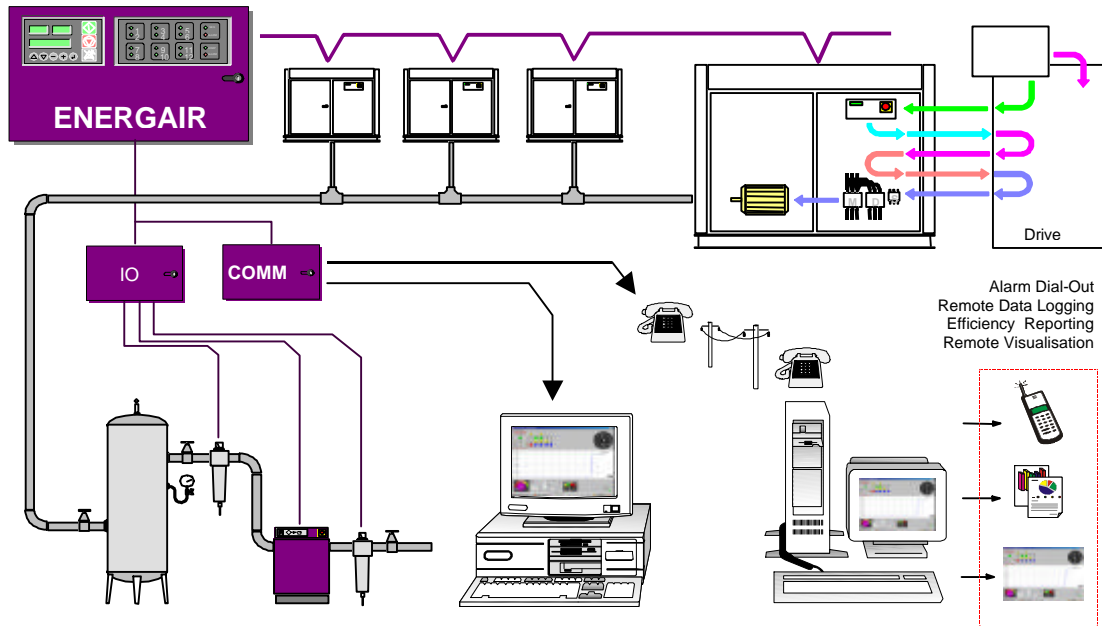
Example site



Recommendation 2

In order to manage the compressed air system in an efficient way, inclusive of a variable speed drive air compressor, we recommend the installation of a new management control system, replacing the existing MVS8000.

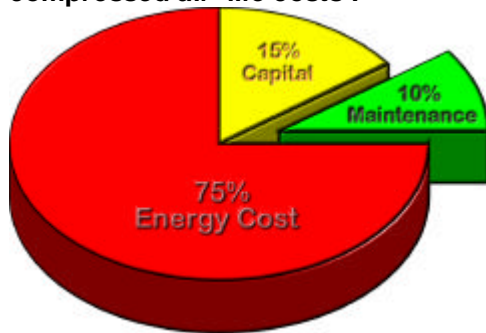
In addition to having the capability to manage both fixed speed and variable speed air compressors in an efficient and coherent way, the management control system will be capable of monitoring the entire compressed air system.



The result is an efficiently managed compressed air system with condition monitoring of compressors and their associated air treatment and ancillary equipment within the compressor house.

An important feature of the Management system will be an embedded datalogger, which will continuously monitor system efficiency. The data logger will provide logged data for efficiency reporting using the software package used to generate this 'initial' report.

The data logging and efficiency reporting is recommended against a backdrop of compressed air 'life costs'.



With energy representing typically 75% of life cycle costs and a cost of energy calculated annually at £ 104,134 per annum, an efficiency-reporting package to ensure that system efficiency is maintained is required.

Trending of report data will identify how effective improvements have been and also what compressed air strategy should be employed into the future.

Efficiency reporting will be done remotely via an industrial modem, which forms part of the system. Additionally, key data such as service due conditions and alarms can be routed directly to your service provider for enhancements to your subcontractor services.

Energy Savings

Two principle areas have been identified for energy savings and our recommendations address them.

Item 1: Reduction in off-load 'non-productive' energy & its cost

By using a 'retro-fit' variable speed drive on compressor 2,3 or 4 as recommended previously we would expect to reduce off-load or non-productive energy consumption by around 90%.

90% of off load or non-productive energy cost is equal to £13,689.77 per annum.

Item 2: Reduction in overall system pressure

The existing MVS8000 controller is operating between 6.6 & 6.4 bar whilst site pressure requirements are for a continuous supply of 6 bar.

By using advanced control software embedded within our management system, we are able to reduce pressure at the compressor to more closely match site demand.

As a result, the elimination over pressurisation in the system will save up to £6,439 per annum.

Summary

Total potential energy savings on this site amount to £ 20,128.77 per annum.

Note:

All calculations above do not take into account the additional cost of the Climate Change Levy, which comes into force in April of 2001. Any additional costs as a result of the Climate Change Levy should be added to your total energy costs associated with compressed air. Resulting energy cost savings are equally proportional.

USEFUL WEB SITES FOR FURTHER REFERENCE INFORMATION.

- www.eca.gov.uk - for qualifying equipment and ECAs
- www.etsu.com - for data regarding energy efficiency and sustainable energy technology
- www.greendrives.com - for information on the role of drives in energy saving applications
- www.energair.co.uk - for information on energy management of compressed air systems.

Note 1:

THE CLIMATE CHANGE LEVY

The Climate Change Levy, announced by the Government in 1999, the UK's response to the Kyoto Summit on Global Warming held in December 1997, At that summit Her Majesty's Government (HMG) made a legally binding commitment to reduce the UK production of a basket of 6 greenhouse gasses by 12.5%, but also made a manifesto commitment to reduce the UK production of CO² by 20%. These targets are for a reduction on 1990 levels for the period 2008 -2012.

The Climate Change Levy is the result of these commitments. Basically a tax on energy usage by business and commerce, the CCL is designed to motivate business and commerce to adopt energy efficiency measures, leading to a reduction in CO². Under the levy the cost of gas, coal, LPG and electricity will rise by a constant levy per kWhr equivalent. As electricity is generated by burning the other fuels, at an efficiency no better than about 35%, it will carry a levy of 0.43p/kWhr. Assuming a consumer is paying 3p/kWhr at present, which is an increase of 14.3% on current prices. This will take effect in April 2001.

Note 2:

WHAT ENHANCED CAPITAL ALLOWANCES (ECAs) MEAN FOR YOUR COMPANY

The strong argument for investigating the energy saving possibilities of drives in compressor applications has been made more compelling by the provision, within the Government's Climate Change Levy Package, for enhanced capital allowances (ECAs) on eight categories of equipment, variable speed drives being one of the categories. (for more information log onto www.eca.gov.uk)

Under the ECA scheme companies who purchase VSDs for energy saving applications, from the approved list of suppliers, will be able to offset some, or all, of

the full cost, along with any capital costs incurred on the installation of the VSD, against corporation tax in the year of purchase. This gives a cash flow benefit and is estimated at about 5% discount off the capital cost.

If a VSD is purchased from the list of qualifying VSD's enhanced capital allowances can be claimed on the cost of that VSD along with any capital costs incurred directly on its installation. In order to do this, companies will need to keep a record of their expenditure, i.e. their invoice statement in order to claim on the correct amount.

The provision of ECAs is not limited to new installations. Companies with "mature" installations can also benefit. In the past the retrofitting of drives to older installations was viewed as too difficult. The Control Techniques/EnergAir partnership overcomes this problem. The Enercon Management System with its comprehensive interfacing facilities enables integration of the Unidrive and the savings to be made.