Energy Management Training:
Making Savings in Compressed Air

tarsheedAD.com

Why use compressed air?

- It is flame/explosion proof.
- It offers a high power output from compact equipment.
- It is extremely reliable.
- It is generally extremely safe to use so long as some basic precautions are followed.
- It does not release harmful gases when used.

Problems with compressed air - energy

- It is made by compressing a compressible fluid.
- According to the gas laws, as pressure is increased, volume decreases and the internal energy of the gas rises, causing the temperature to increase.
- At the end of the compression process, the air cools down and the ratio between the constants means that around 80-90% of the energy put in to compress the gas is lost as heat.
- Compressed air has a round trip energy efficiency of around 10-20%.
- So if your air tool delivers 1kW of power, you must put in 5-10kW of power in your compressor to drive it!

Problems with compressed air - leakage

- Air is a very low viscosity fluid:
  - Viscosity of olive oil at 20°C = 0.056 Pa.S
  - Viscosity of water at 20°C = 0.001 Pa.S
  - Viscosity of air at 20°C = 0.0000182 Pa.S
- Air flows through gaps 55 times more easily than water.
- It is able to escape at high rates, even from small leaks:
  - Many small leaks can add up to a large overall rate. A system may contain thousands of joints, each of which can contribute.
  - The sound from escaping air may be hidden by the noise of surrounding machinery.
  - So air leaks are easily missed and overall leakage rates may be higher than 50%.

What does a leak look like and cost?

- Because of the low viscosity, small holes give large leakage rates.
- Because air distribution systems are frequently subject to mechanical loads, wear and tear means that many small leaks can develop over time.

Leak Diameter (mm)	Loss Rate (Litres/Second	Power Wasted (kW)	Annual Cost 48 hr Week	Annual Cost 120 hr Week
0.4	0.2	0.1	12	30
1.6	3.1	1	120	300
3	11	3.5	420	1,050

Leakage best practice is 5-10%, but > 50% is common.

Where does compressed air leak?

- Piping joints.
- Quick release couplings.
- Pressure regulators.
- Valves.
- Damaged hoses.
- Corroded pipes and fittings.
- Condensate drain valves.
- Worn seals in actuators.
- Sub-systems in equipment being used.
- Sub-systems in unused equipment.

Distribution leakage for fixed speed compressors

- Isolate all air-using equipment from the distribution system.
- Run compressor and distribution system at normal pressure.
- Looking at the compressor load, record the durations of the on-load cycle (T) and the off-load cycle (t).
- Obtain the litres/second capacity of the compressor (Q) from manufacturer's data.

$$Leakage\ in\ litres\ per\ second = \frac{Q\ x\ T}{(T+t)}$$

Checking leakage for modulating compressors

- Isolate all air using equipment from the distribution system.
- Pump the system up to full pressure.
- Isolate the distribution system from the compressor.
- Record the time taken for the system to run down from starting (P_1) to finishing pressure (P_2) in bar.
- Find the volume of the whole system in litres from construction engineering specifications or through estimation.

$$Leakage\ in\ litres\ per\ second = \frac{System\ Volume\ x\ (P_1 - P_2)}{Time}$$

How can I check my machinery leakage?

- Machinery usually uses compressed air for actuation.
- Machine movements and vibrations impose stresses on both machinery pipework and actuators:
  - Seals and joints are subject to fatigue.
  - Actuator seals and bores are subject to mechanical wear.
- This natural working damage means that losses on machines can gradually grow to be large.
- To check losses on machinery, perform the leak tests from the previous slide, with the machinery inactive but not isolated from the system.
- Depending on the configuration of the equipment, you may need to add a pressure gauge behind the shutoff valve.

How can I find leaks?

- Mk 1 ear:
  - If you can just hear it, it is costing around 5AED per year.
  - If it quite noticeable, the cost may be nearer 50-100AED per year.
  - A loud leak my be losing hundreds or thousands of AED/year.
  - Each leak that fulfils these criteria adds to the total cost!

- Hand spray with soap bubbles:
  - Spray joints and look for bubbles.
  - Cheap and effective, but slow and a little messy

- Ultrasonic leak detector:
  - Finds small, inaudible leaks – small but numerous.
  - Fast and time efficient process.
  - Costs 200-800 AED for a cheap unit, up to 4,000 plus for a high quality one.

Practical routines for finding and managing leaks

- Combined find-and-fix process:
  - Could use a regular survey & fix team tour.
  - Detect and fix when found.
- Separate finding and fixing processes:
  - Regular dedicated survey to detect and label.
  - Follow-up maintenance team fixes when convenient.
- Grass roots process:
  - Make up some high visibility leak labels with easy-to-use card labels and metal hooks.
  - Position stocks of them around the plant in “Leak stations”
  - Train staff to attach labels to any leaks that they find.
  - Maintenance team finds them and fixes when convenient.
  - Surveys to confirm the effectiveness of the process.

What about pressure?

- Reducing pressure reduces the work to compress the air.
- The rule of thumb is that if you reduce the pressure by X%, the energy consumption will reduce by X/2%.
- Reducing from 7 bar to 5.6 bar (20%) will cut costs by 10%.
- Agree a formal experimentation plan with production management to gain support.
- To reduce pressure without risking production, make reductions in increments, checking the functioning of equipment at each step.
- Carry out the pressure reduction experiments at the end of production shifts or out of hours.

Examples – Poor quality distribution systems

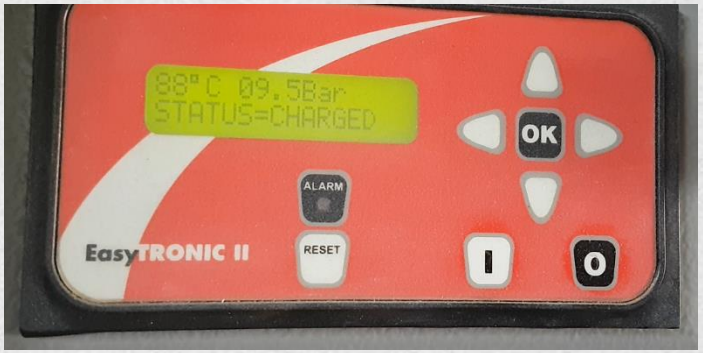
- Dilapidated system with widespread hissing?
- Leakage could be as high as 60% - 80%!

Large mains leak with entirely ineffective attempt at repair

Incorrectly stuffed pipe joint with leak

Examples: compressed air generation

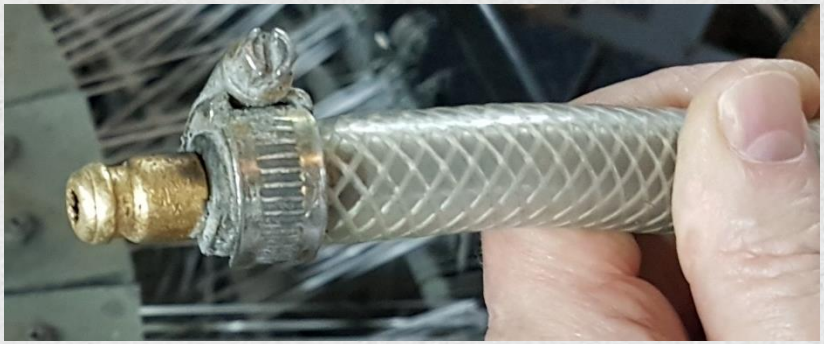
- What are compressor capacities?
- What pressure is system set at?
  - Normal industrial level is 7 Bar.
- Is an air drier present? Is it working?
- How clean is the compressed air?
  - Water and oil should stay in the traps!



Highest pressure that I have ever seen!

Efficient use

- Is equipment getting the pressure it really needs?
- Is each element using the air efficiently?



Home made blower nozzle for cleaning.
A proper trigger operated venturing nozzle saves more than 40% of consumption.

Actuator with too high a pressure:
Excessive wear and tear on bearings.

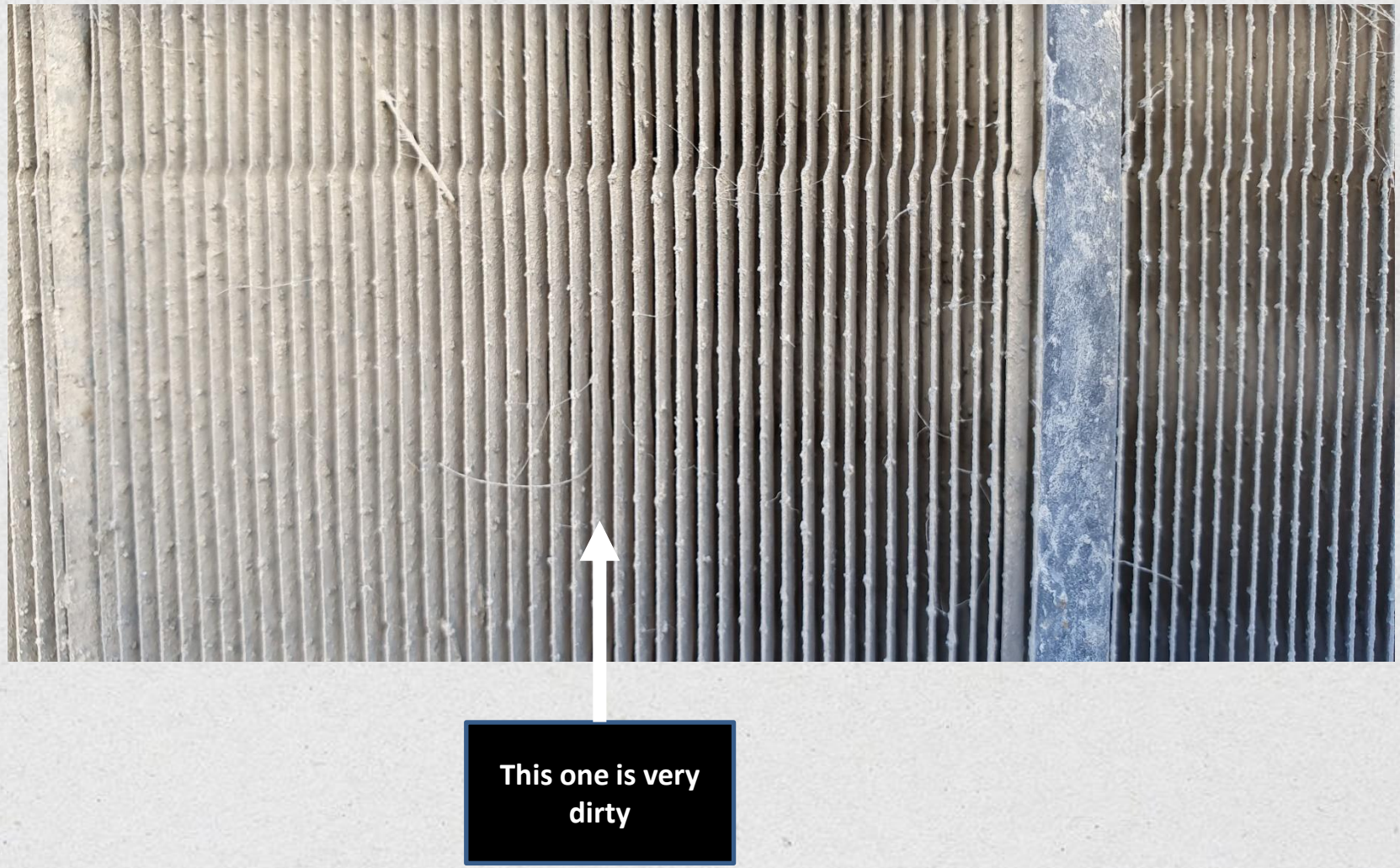
Pressure requirements may be different

- Sometimes not all equipment on the system needs the same pressure in order to function correctly.
- The standard industrial pressure is 7 bar, but some equipment may need 9 bar and some 5.5 bar or less.
- In these cases, it may be worth splitting your mains into two systems, a high and a low pressure line, each with a dedicated compressor.

Unsuitable uses for compressed air

- Stirring liquids.
- Air movement.
- Materials conveying.
- Cooling.
- Not all of these applications can be substituted with more energy efficient technologies, but some can:
  - Electric stirrers.
  - Electric motors and fans.
  - Venturi fans.
  - Intermediate pressure blowers.
  - Mechanical conveyors.

Clean heat exchangers are more efficient



Pre-cooling air saves compressor energy

- For the intake air to the compressor:
  - The cooler the air that you actually compress, the less energy will be needed to compress it.
  - Energy consumption drops by a little over 1% for every 3°C drop in inlet air temperature.
  - Ensure that outside air is used, not air from within the hot machine enclosure.
  - A segregated adiabatic pre-cooler for the inlet air delivers the coolest air.
- For rejecting the waste heat from the compressor:
  - The cooler the heat exchangers are, the lower the system power consumption.
  - Water-cooled compressors with wet cooling towers offer the highest intrinsic efficiencies.
  - For air-cooled compressors, retrofitting adiabatic pre-cooling pads on heat exchangers will improve the compressor efficiency.

Examples of how savings can build up:

- Reduce pressure:
  - 16% savings (9.5 Bar to 7 Bar)
- Reduce leaks:
  - 55% savings (60% to 5%)
- Overall savings:
  - Compounded to yield 62%
- How much will this save per year?
  - 12,367 AED/Year on a small to medium-sized system
- Investment: Negligible or low.

Summary

- Compressed air is the fastest and cheapest way to make energy savings.
- Quick wins include:
  - Find and fix leaks.
  - Optimise system pressure settings.
  - Eliminate inappropriate use.
  - Optimise control to reduce pressure peaks.
- Capital intensive measures include:
  - Bring modulating compressors into the system.
  - Segregate systems for low and high pressure demand.
  - Pre-cool intake air and heat exchanger cooling air.