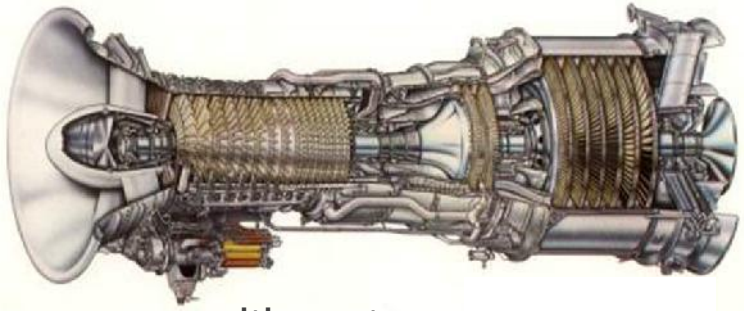
CLARCOR

Industrial Air

Nonwovens in Gas Turbine Air Filtration – Past, Present and Future

By Steve Hiner

What is a Gas Turbine?



- A high value asset (Many $MM's)
- Used for driving
  - Electrical generators
    - Gas power stations, ship power, platform power, smelting etc.
  - Pumps and compressors
    - Pipelines, refineries, chemical plants, LNG compression etc.
- Also produces
  - Steam
    - To feed steam turbines to produce more power, chemical plant processes etc.
- The value of the process that it drives can be very large, e.g. shutting down an LNG plant can cost $10-20 MM's per day!

GT’s consume an enormous amount of air

Wembley Stadium

- Seats 90,000
- Volume of 4 million cu m (5 million cu yards)

Time taken for GT to consume all the air in Wembley Stadium:-

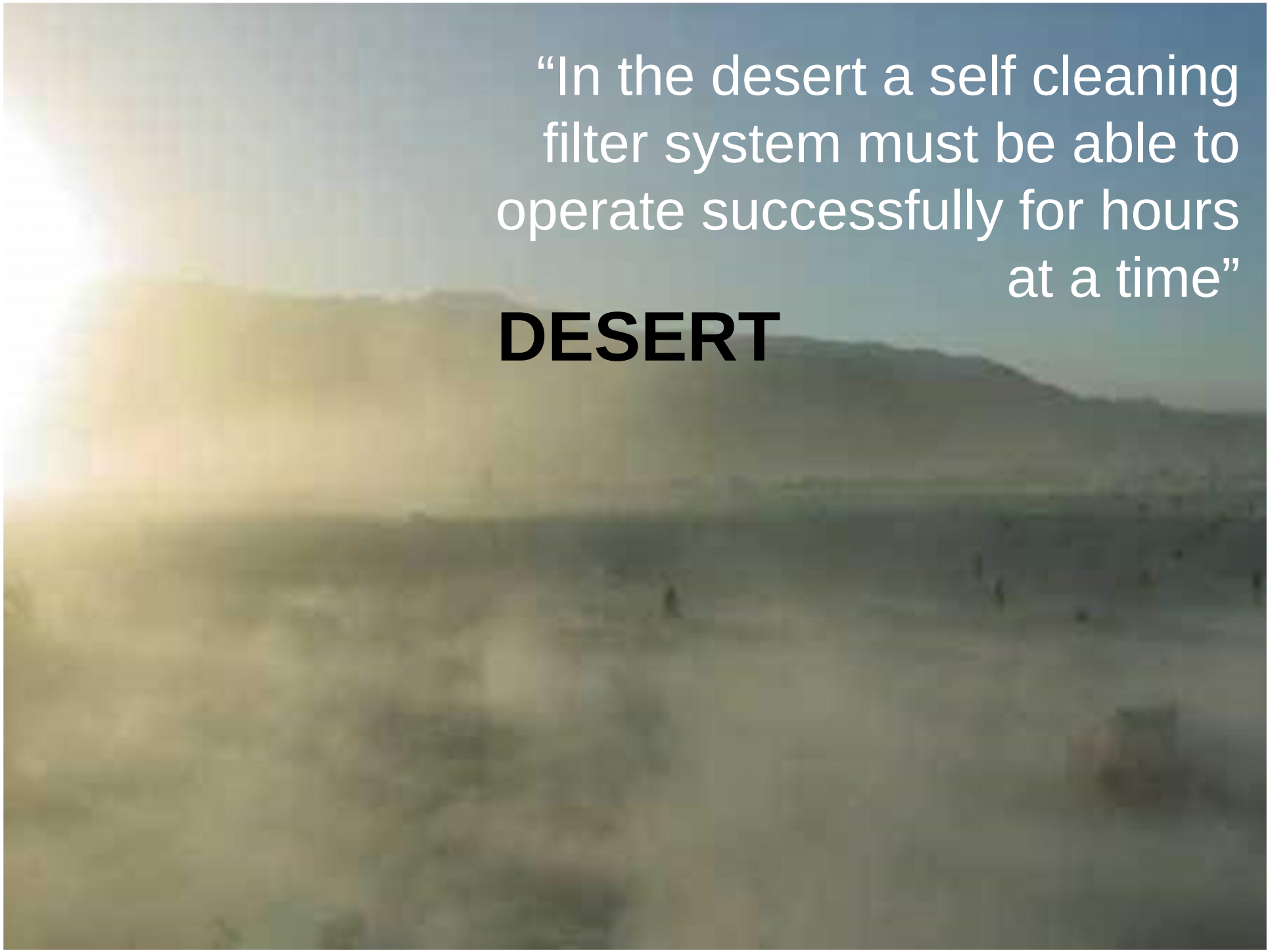
- GE LM2500 ….in 17 hours
- GE Frame 9 ….in 2 hours


Gas Turbines are used in all
Environments of the World


“In the offshore environment
the trouble-free operation of a
gas turbine is a continual battle
against the elements”
OFFSHORE


“ The marine environment represents a unique challenge…
MARINE
…both for gas turbines and the air inlet filtration systems that protect them.”


“The dusty coastal environment can be the most challenging of all”
DUSTY COASTAL


“In the desert a self cleaning filter system must be able to operate successfully for hours at a time”
DESERT


“Low temperature climates introduce new and unpredictable challenges”
ARCTIC

Unique staging is tailored to the Environment

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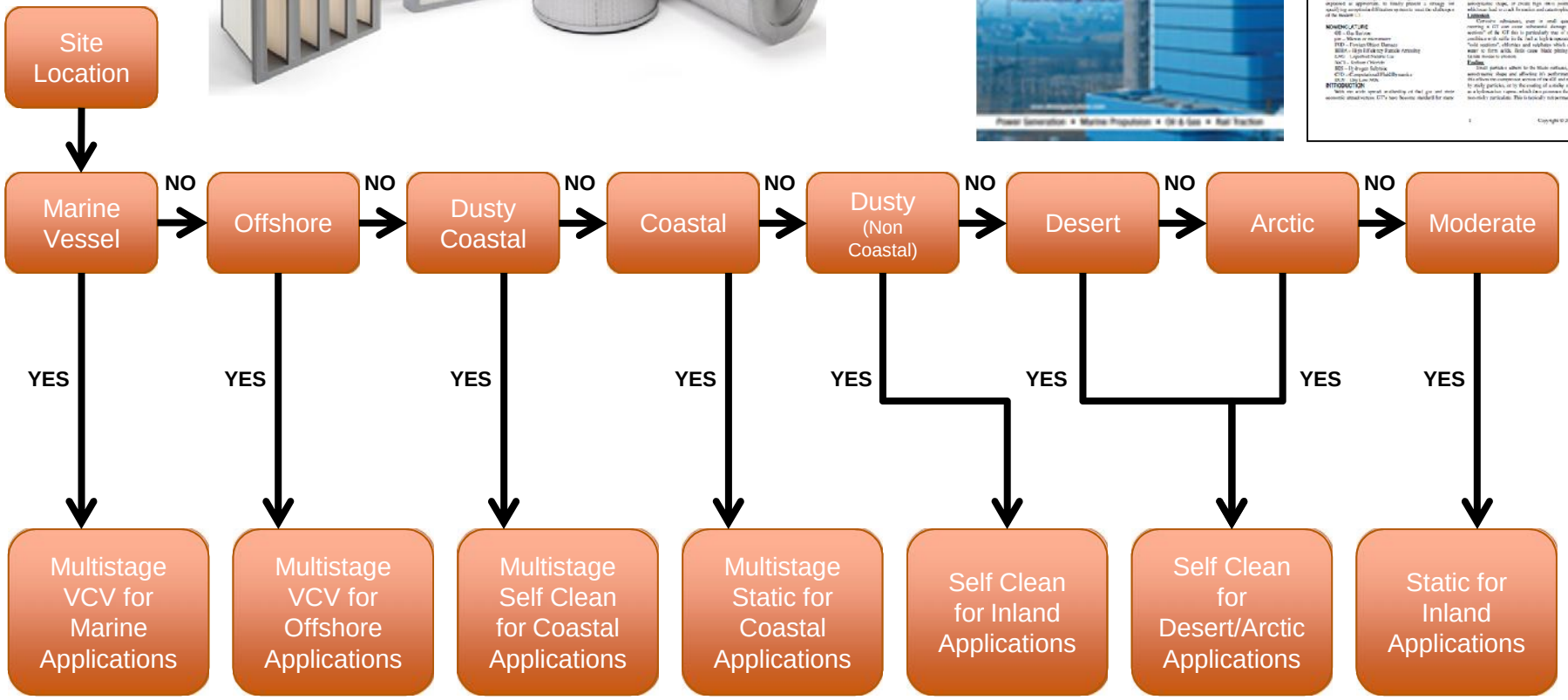

Gas turbines come in all sizes - can use fewer than 9 filters ….


… or greater than 1,000
filters

All filter types utilised

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Panel filters

- Used as a pre-filter or droplet coalescer
- Life typically 3 to 6 months, disposable
- Efficiency between G2 to M5 vs. EN779:2012
- Typical current media:-
  - High loft coarse fibre glass mat
  - Knitmesh
  - Wire backed and pleated carded cotton
  - Thermally bonded air laid synthetic
  - Needle felt

- Future trend
  - Synthetic media with self supporting pleats
  - Glue bead pleatable synthetic; Spunbond or Meltblown

Pocket filters

- Most often used as a pre-filter
- Life typically 1 to 2 years, disposable
- Efficiency between G3 to F7 vs. EN779:2012
- Typical current media:-
  - Lofty micro fibre glass
  - Needle felt
  - Thermally bonded air laid synthetic
  - SMS

- Future trend
  - Mechanical filtration, no charging
  - Multi layer, synthetic media with fine fibre meltblown
  - Advanced coatings

vCell filters

- Used as an intermediate pre-filter for EPA+ final filters, or as the final filter
- Life typically 1 to 3 years, disposable
- Efficiency between F7 to F9 vs. EN779:2012 and E10 to H13 vs. EN1822:2009
- Typical current media:-
  - Wet laid micro fibre glass
  - Synthetic composites with fine fibre meltblown
  - Synthetic composite with ePTFE
  - Fluorocarbon hydrophobic treatments

- Future trend
  - Multi layer, synthetic media with fine fibre meltblown or other nano fibre
  - Micro fibre glass / synthetic composites
  - Advanced coatings

Cartridge filters

- Most often used as the final filter but sometimes as the pre-filter for hydrophobic or EPA+ vCell final filters
- Majority used in reverse pulse self cleaning systems
- Life typically 2 to 4 years, disposable
- Efficiency between M6 to F9 vs. EN779:2012 and E10 to H12 vs. EN1822:2009
- Typical current media:-
  - 100% Cellulose paper
  - Blended (80/20, 90/10) cellulose / synthetic wet laid
  - Wetlaid synthetic
  - Spunbond
  - Electrospun nano fibre on all substrates
  - Microfibre glass / synthetic composites
  - Synthetic composites with ePTFE
  - Fluorocarbon hydrophobic treatments
  - Corrugated / rotary pleatable

- Future trend
  - Multi layer, synthetic media with fine fibre meltblown or other nano fibre
  - Advanced coatings
  - Glue bead pleatable

GT filters are tested in many different ways

- Extensive efficiency testing at multiple final pressure losses and flow rates
- Humidity, Mist and Fog reaction testing
- Wet saturation testing
- Extensive burst testing (wet and dry) up to a 72 hour test
- Extensive self cleaning performance testing up to a 200 hour test
- Rough handling vibration and drop testing
- Hi (up to 90C / 194F) and low (down to -60C / -76F) temperature extreme suitability testing
- Product aging testing
- Extensive hydrophobic performance testing up to a 10 day test.
- Dry and wet salt removal efficiency testing
- Gasket leak testing
- Long term outdoor testing

Anatomy of a Gas Turbine

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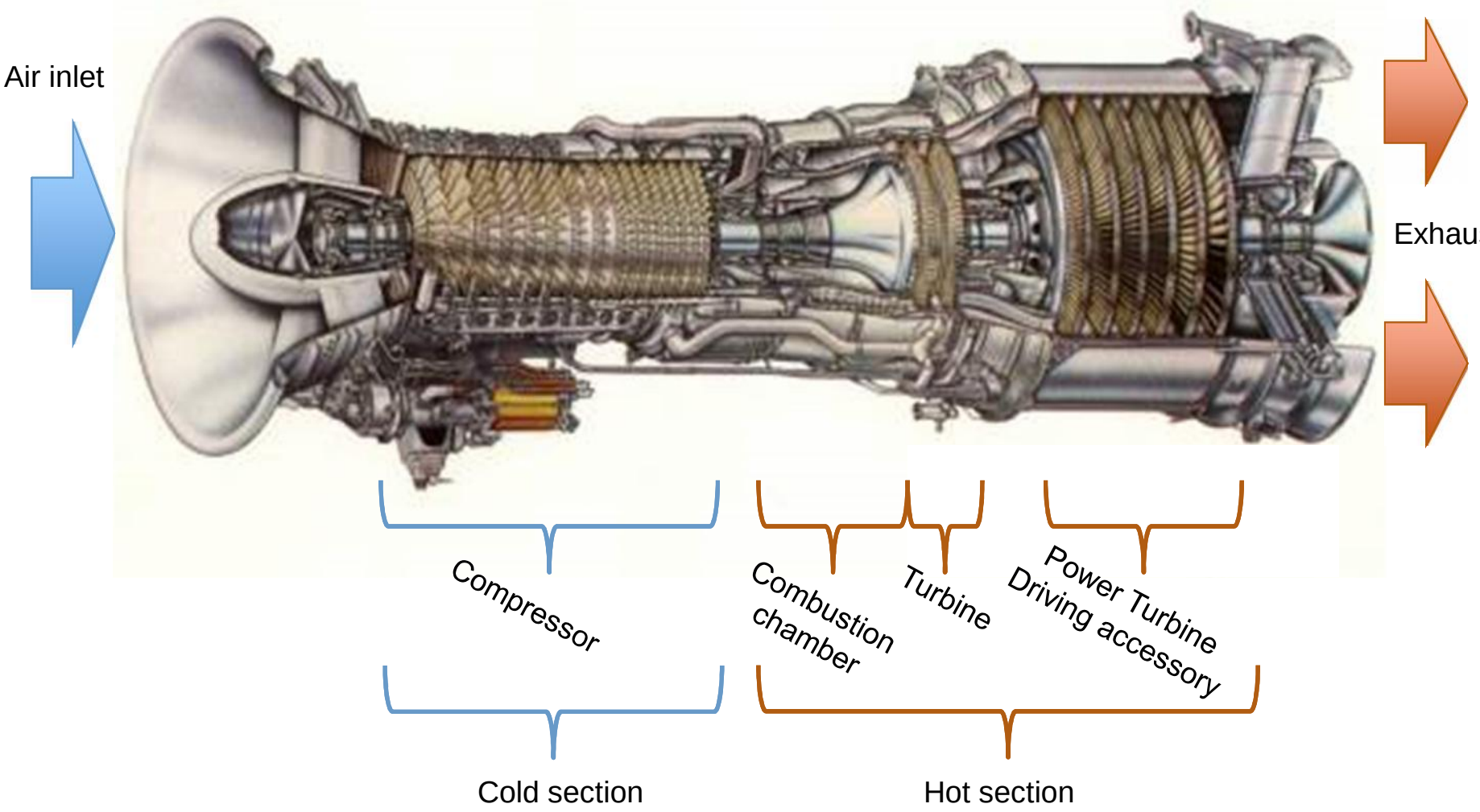

… consequences of poor inlet filtration

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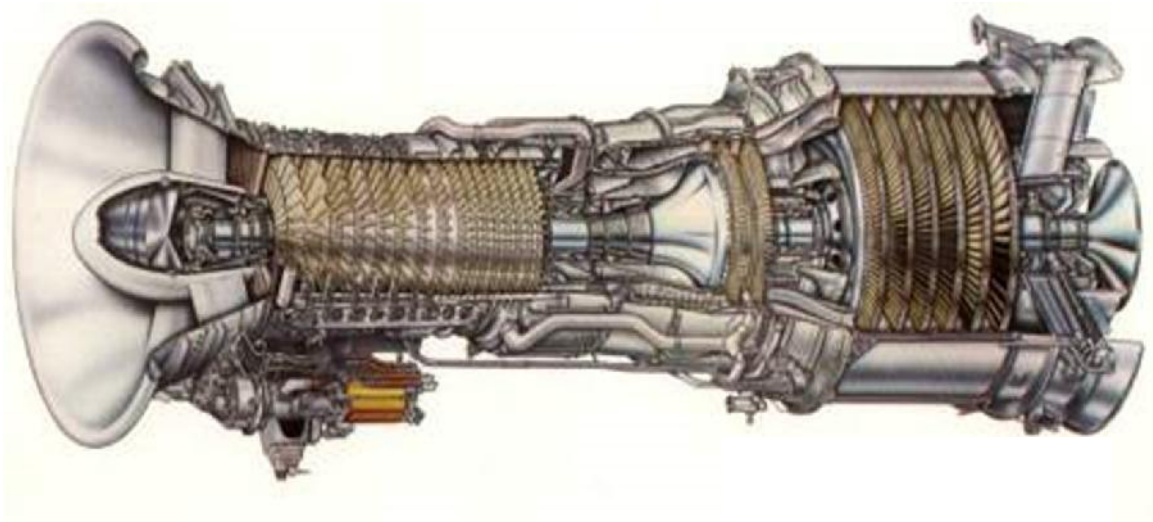
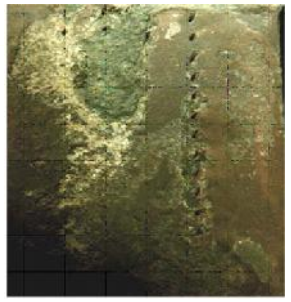


Foreign Object Matter

Erosion

Fouling

Cooling passage plugging



Particle fusion

Corrosion

GT filters eliminate most of these today …

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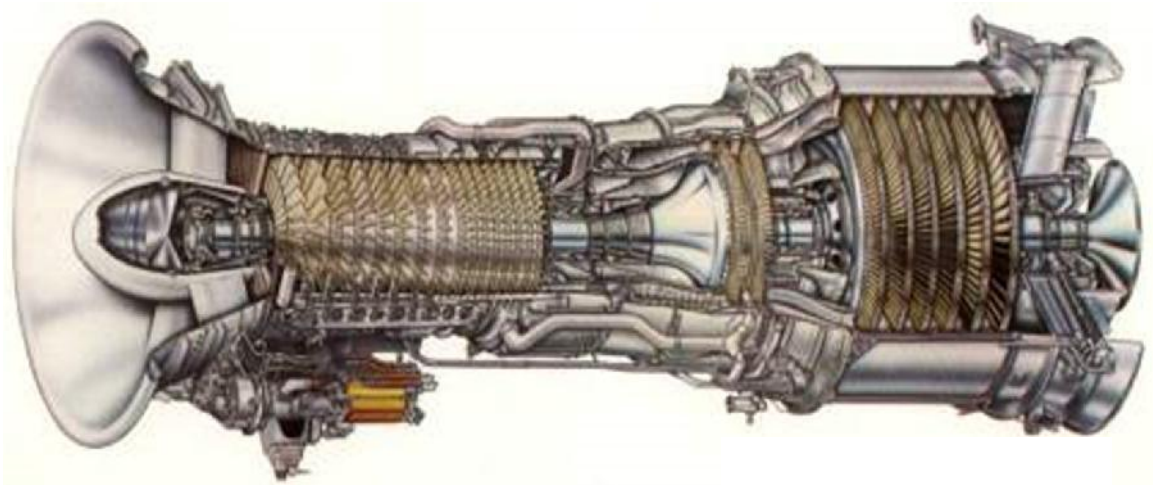

Hot End

Fouling

Corros

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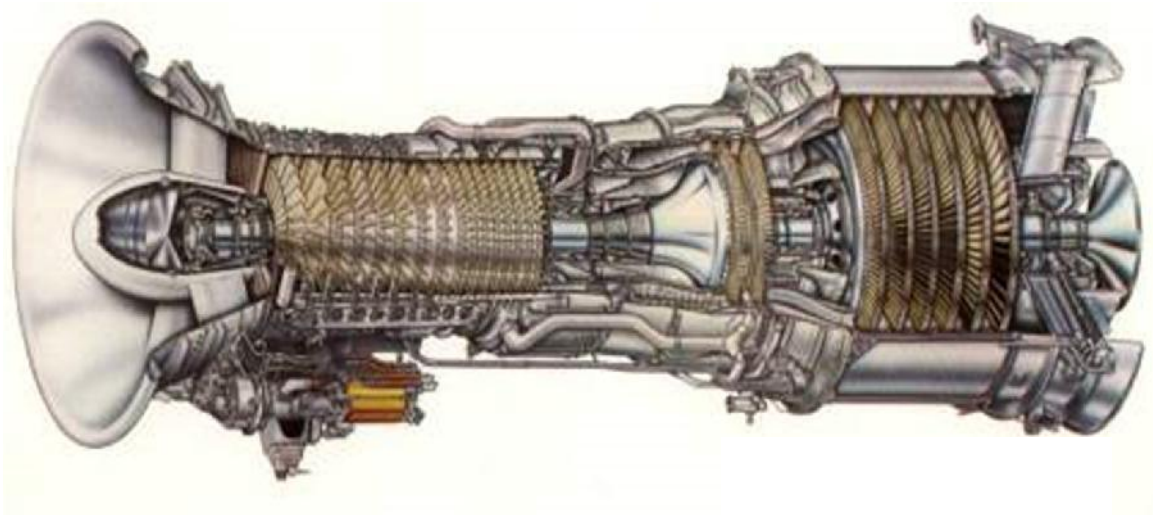

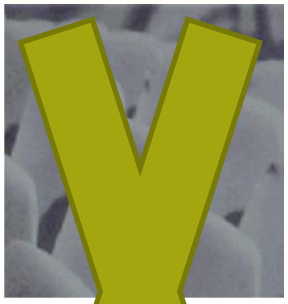

Fouling

Cold End Corrosion

Corrosive contaminants overview

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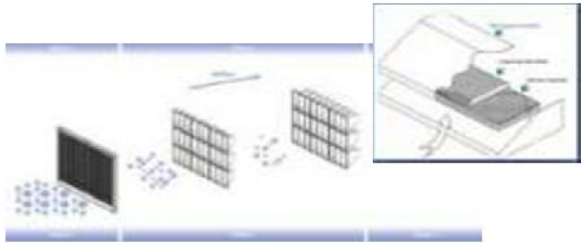
Corrosives

Solids → **Dry salt** → 

Media filters

RH > 65 %
Rain, fog
moisture

Liquids → **Liquid corrosive** → 

Rain, fog
moisture

Water removal stages and hydrophobic filters

Gases / Vapour → **SOx, CL, NOx** → **No filtration system**

Humidity

Corrosive contaminants overview

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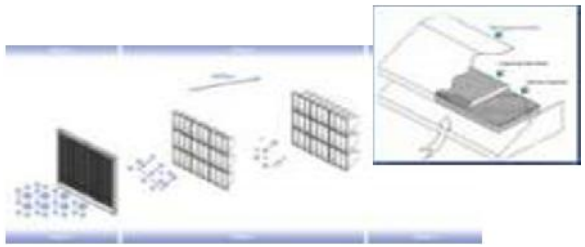
Liquids → **Liquid corrosive** → 

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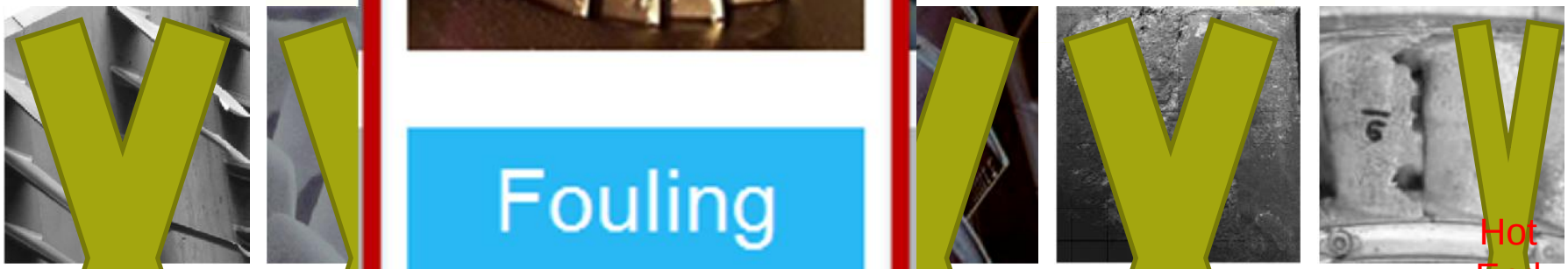


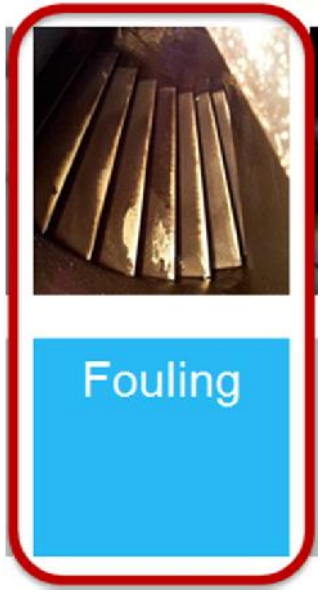
Fouling

Hot End

Corros

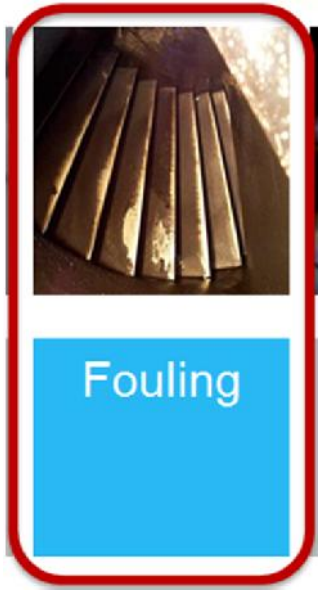
What is fouling?

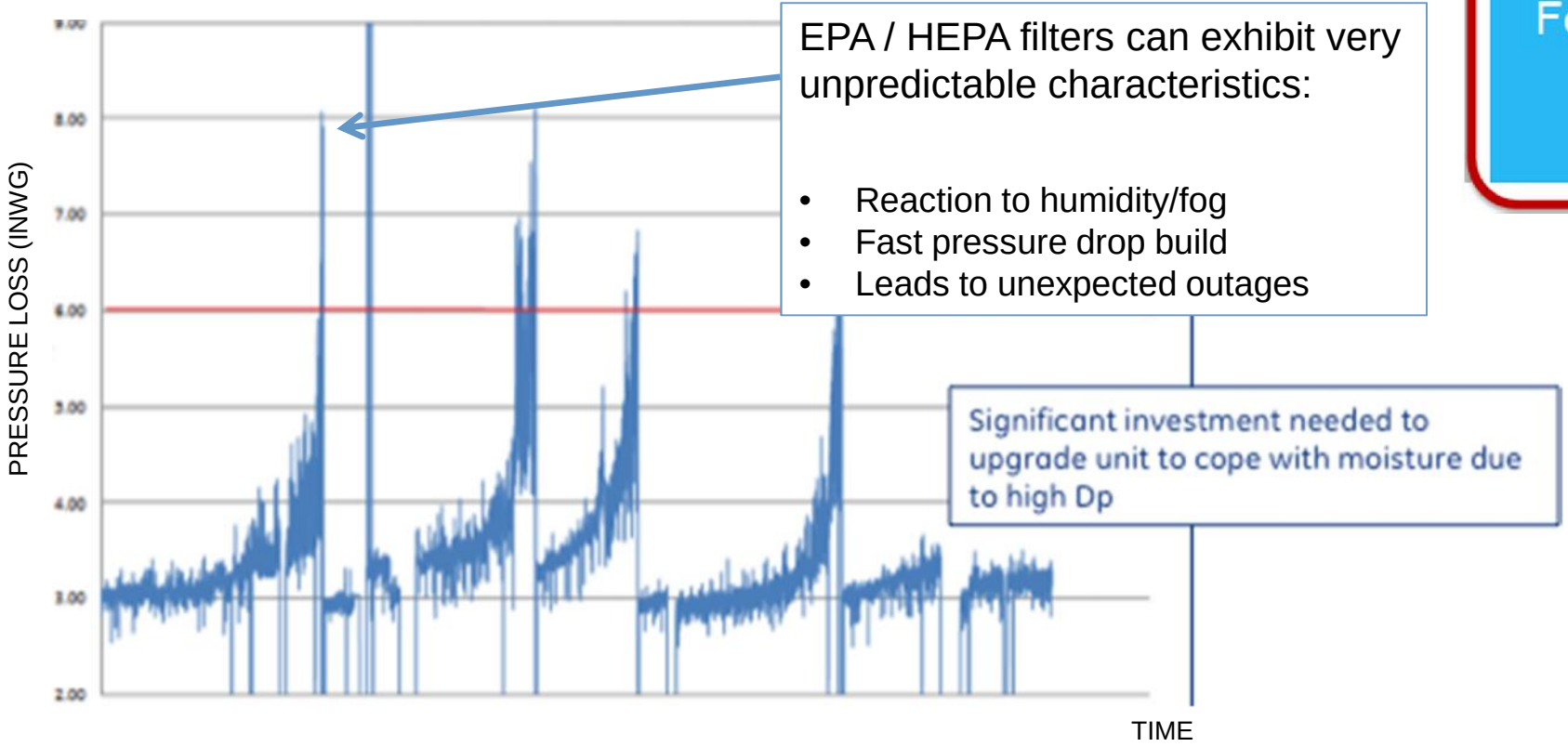
- Fouling is when dirt adheres to the compressor blades which reduces their compression efficiency
- Fouling does not cause permanent damage
- Fouling contaminant is typically <1 micron in size
- The gas turbine is periodically shut down and an “off line wash” is performed to remove the contaminants and restore the compressor to a clean, like new state
- The downtime to wash a GT is typically 24 hours, which for high value processes such as LNG, can result in high financial losses



Two ways to stop fouling –

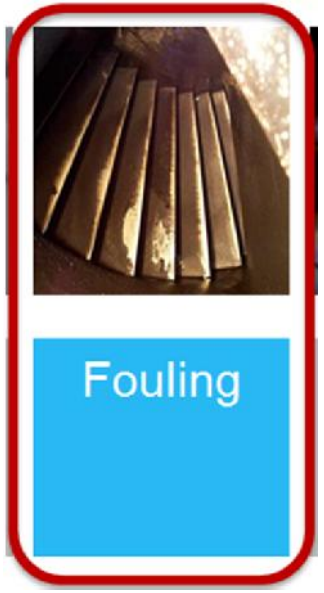
1. Stop fine (<1 micron) particulate reaching the GT
   - Use of high efficiency filters, typically E10 or above
   - EPA / HEPA alone only addresses dry contaminants
   - Filter likely to be more sensitive to moisture



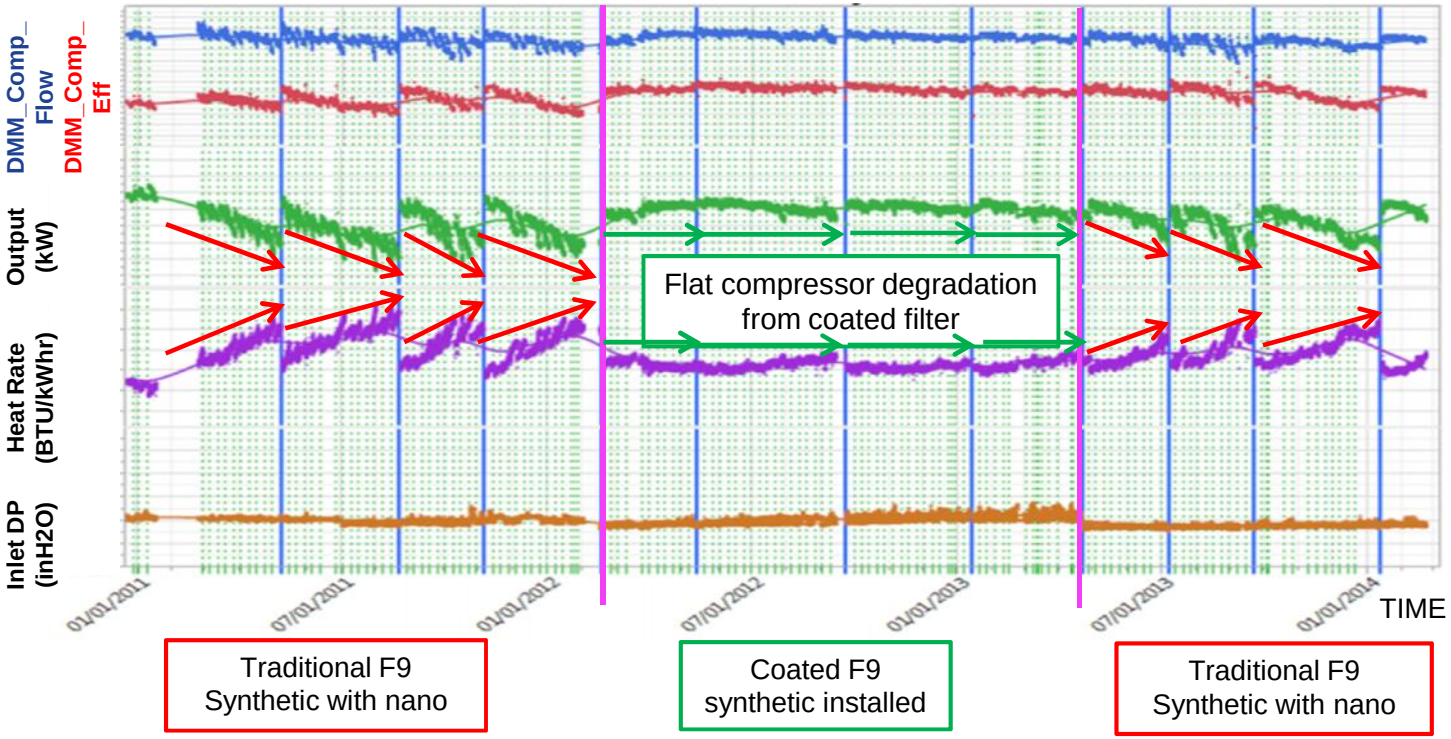


Two ways to stop fouling –

2. Stop contaminants from sticking to the compressor blades
   - Sticky contaminants such as, salts and hydrocarbons etc. are much more likely to cause fouling by making the blades sticky which then enable them to foul with dry inert particulate.
   - Use of hydrophobic and advanced fibre coated filters can significantly reduce sticky contaminants getting to the GT



EXAMPLE



Industry trend

The industry trend is for increased GT availability in all environments while using ever newer, more complex and sensitive gas turbines.

This results in a need for:-

1. Higher efficiency filters – Fine fibre (Nano)
2. Filters with longer life – Multi layer composites that are highly pleatable
3. Filters with predictable performance and no surprises – Advanced coatings with moisture management addressed that have been extensively tested in the real world
4. Robustly designed filters – Strong filter media

Challenges for the Nonwovens Industry

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1. Higher efficiency (EPA / HEPA) media that is less sensitive to mist, fog or hydrocarbons especially when loaded in the real world
2. As 1 above specifically for surface loading media for pulse cleanable products
3. Proven through life (real world) hydrophobic properties
4. Synthetic media that truly holds or improves it's efficiency through real world loading
5. Longer life media
6. Higher strength media that can be pulsed
7. Focus on pleating, self supporting, corrugation etc.
8. Advanced fibre coatings

Essentially there is a growing need for cost effective, composite media using multiple non-woven and coating technologies in a single media available from multiple global locations

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Any questions?