

Performance Evaluation of Underground Mine Diesel Engine Exhaust Insulation Products

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MDEC Presentation
October 2009

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Abstract

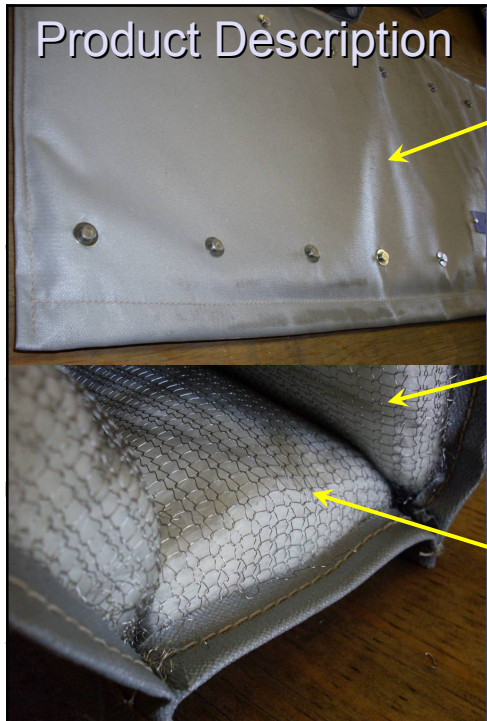
The use of diesel engine exhaust insulation products are widespread and increasing in mobile underground mining equipment applications. Diesel engine exhaust insulation products minimize engine exhaust heat energy loss which can improve the oxidation performance of diesel oxidation catalysts and diesel particulate filters. In addition the passive regeneration performance of diesel particulate filters can also be improved through the use of diesel engine exhaust insulation products. Several types of diesel engine exhaust insulation products are currently offered by a variety of manufacturers. Very little published information is available concerning the thermal properties and performance of diesel engine exhaust insulation products.

In this technical paper 4 different types of diesel engine exhaust insulation products provided by the same vendor are installed onto a 33 kW diesel generator set and are evaluated based on ISO 8497. Each diesel engine exhaust insulation product was installed onto an identical engine exhaust pipe which was instrumented with 6 thermocouples attached to an 8 channel Omega TC-08 datalogger. The thermal insulation performance, heat transfer, insulation surface temperatures and rock impact damage to the surface of insulation are tested and reported. In addition the sound attenuation of each type of diesel engine exhaust insulation was tested and evaluated.

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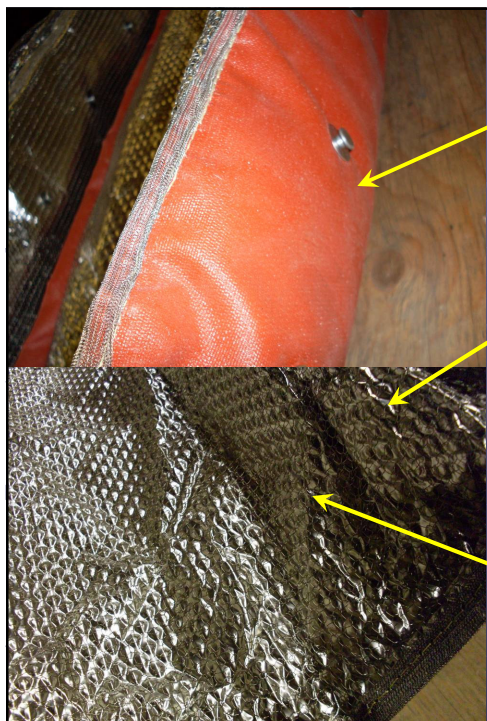
Product Description



- Insulation type CEP STD:
- Outer layer
 - Gray color
 - silicone impregnated fiberglass outer cover
 - Temperature limit of 500 °F (260 °C).
- Middle layer
 - Fiberglass
 - Temperature limit of 1200 °F (649 °C).
- Inner layer
 - Steel mesh (304)
 - Temperature limit of 1200 °F (649 °C).

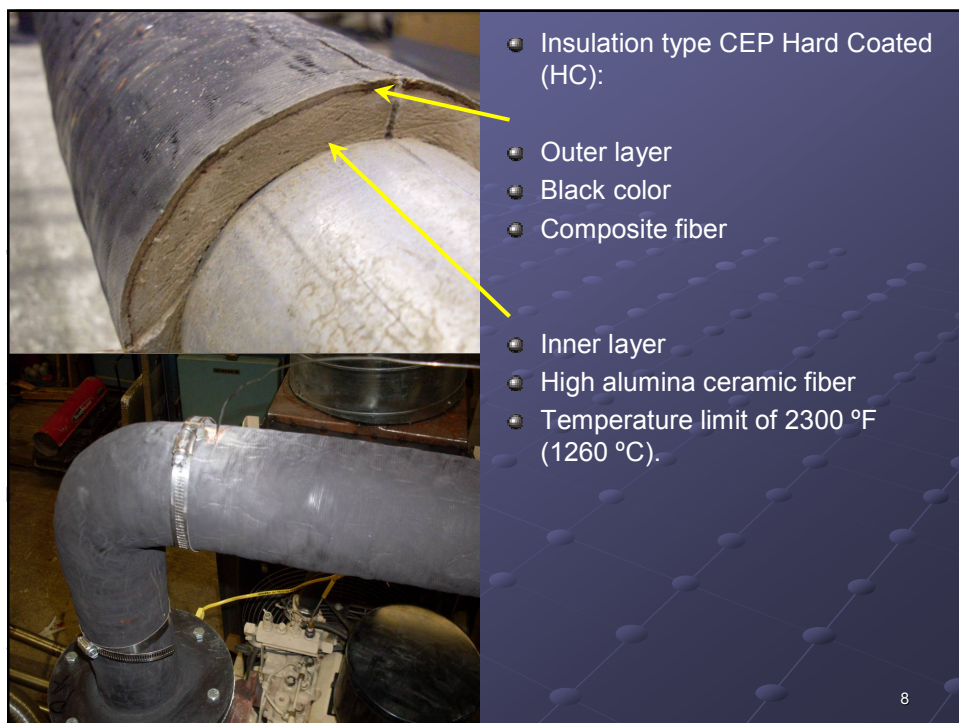
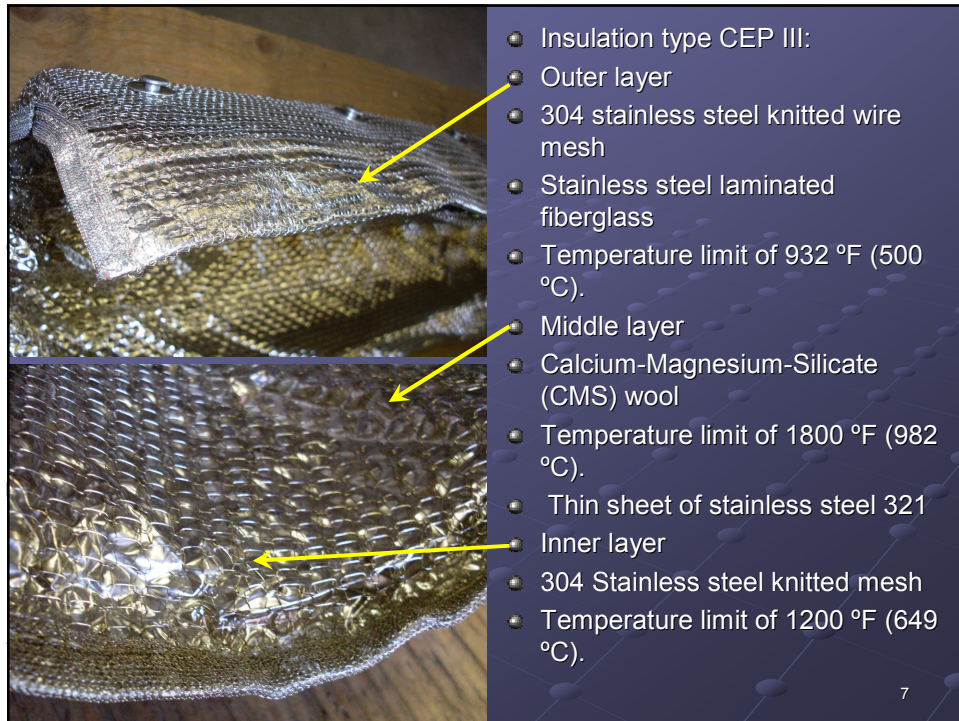
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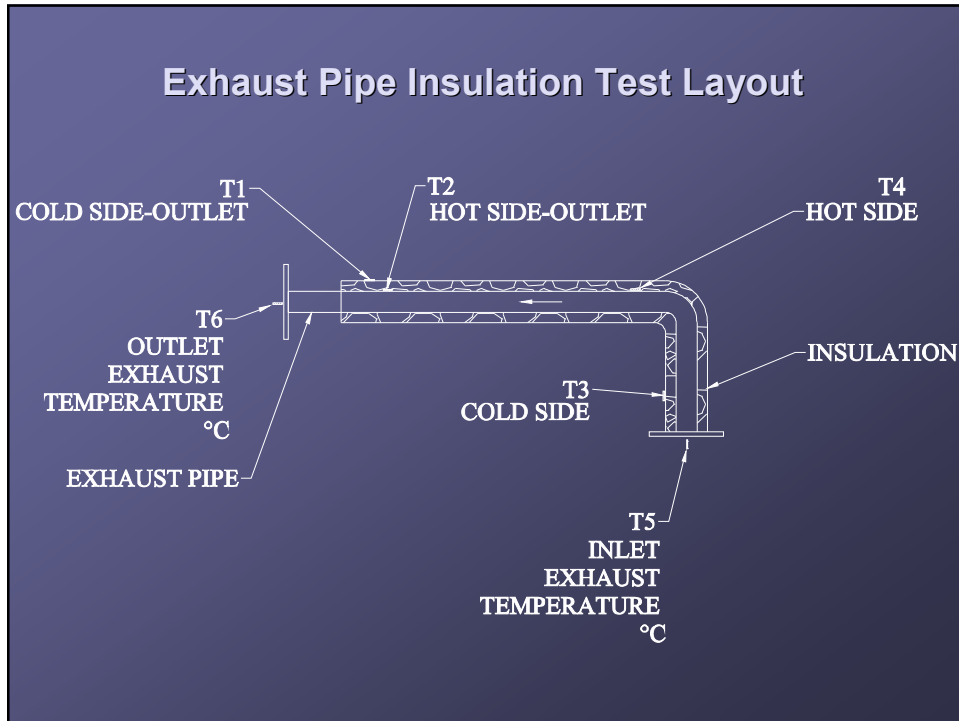
Product Description



- Insulation type CEP II:
- Outer layer
 - Red color
 - Silicone impregnated fiberglass
 - Temperature limit of 600 °F (316 °C).
- Middle layer
 - Calcium-Magnesium-Silicate (CMS) wool
 - Temperature limit of 1800 °F (982 °C).
- Thin sheet of stainless steel 321
- Inner layer
 - Steel mesh (304)
 - Temperature limit of 1200 °F (649 °C).

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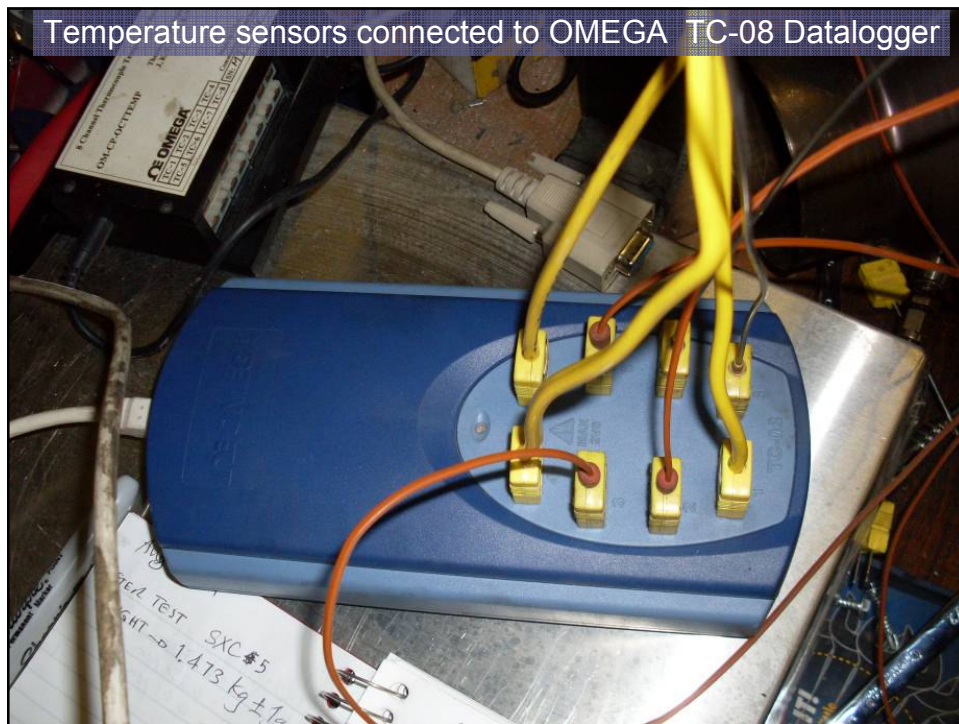
Procedure

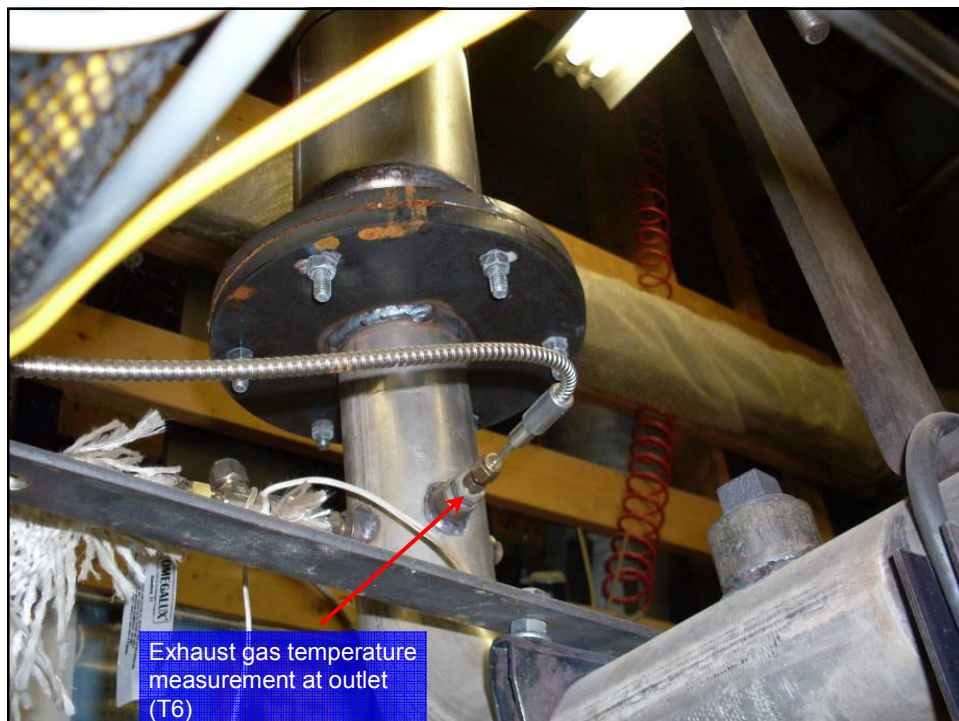
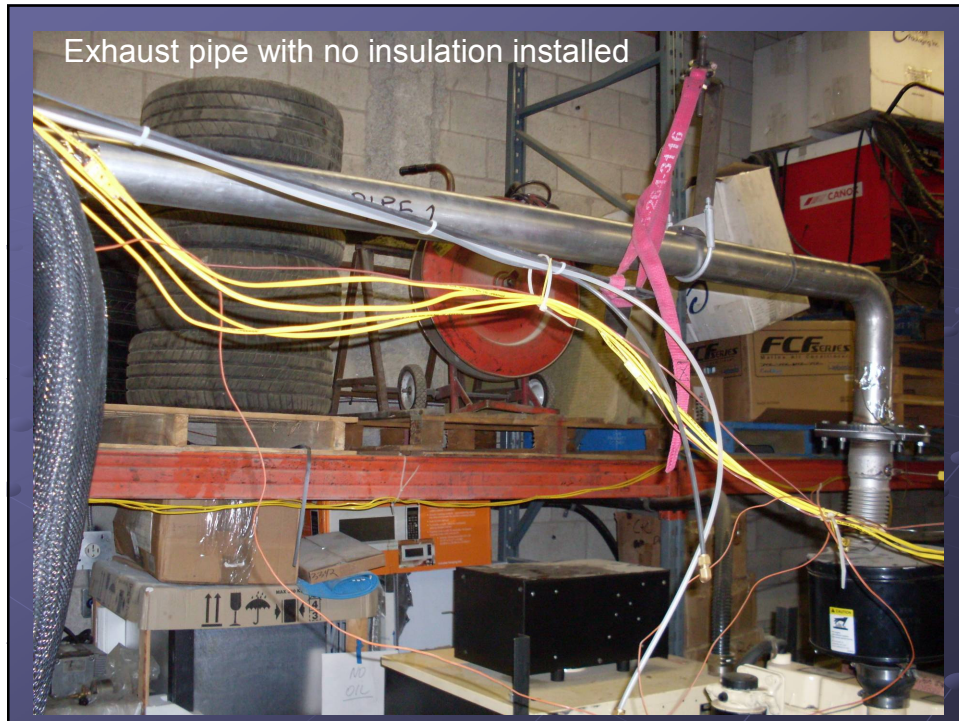
The exhaust pipe of a diesel genset was wrapped with 4 different types of removable insulation blanket.

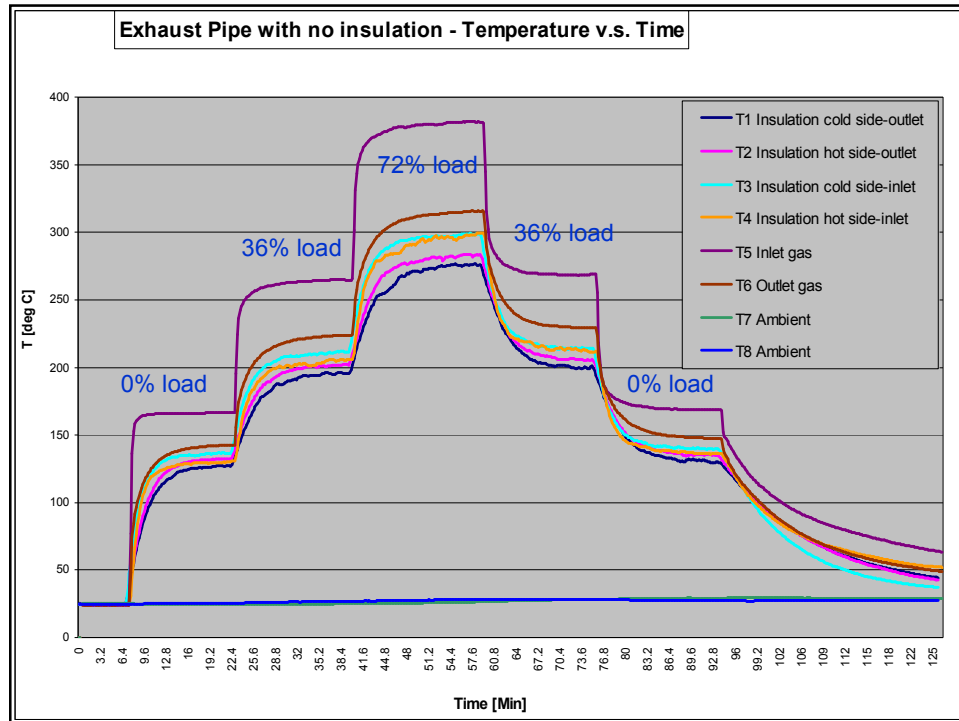
Six sensors were installed on an exhaust pipe insulation as shown in the previous slides.

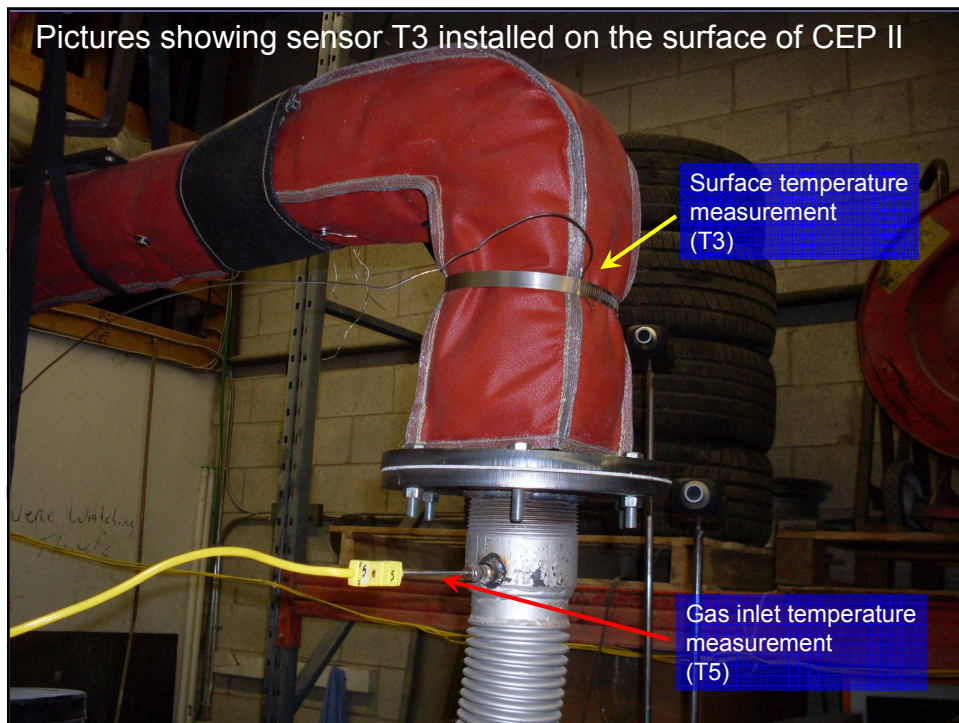
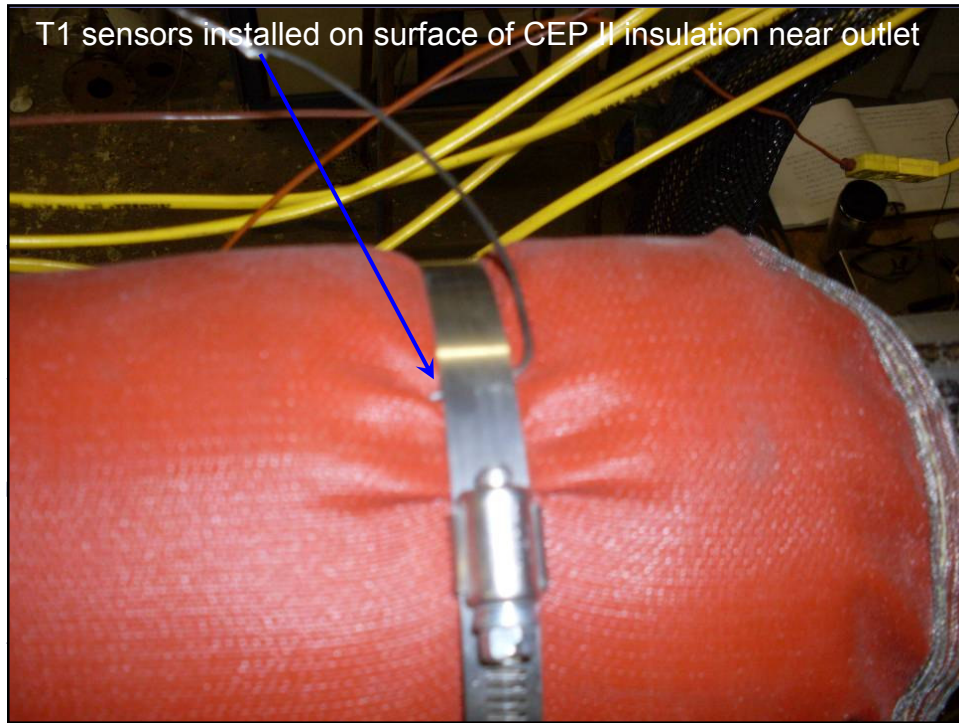
Two extra sensors (T7 & T8) were set to measure ambient temperature.

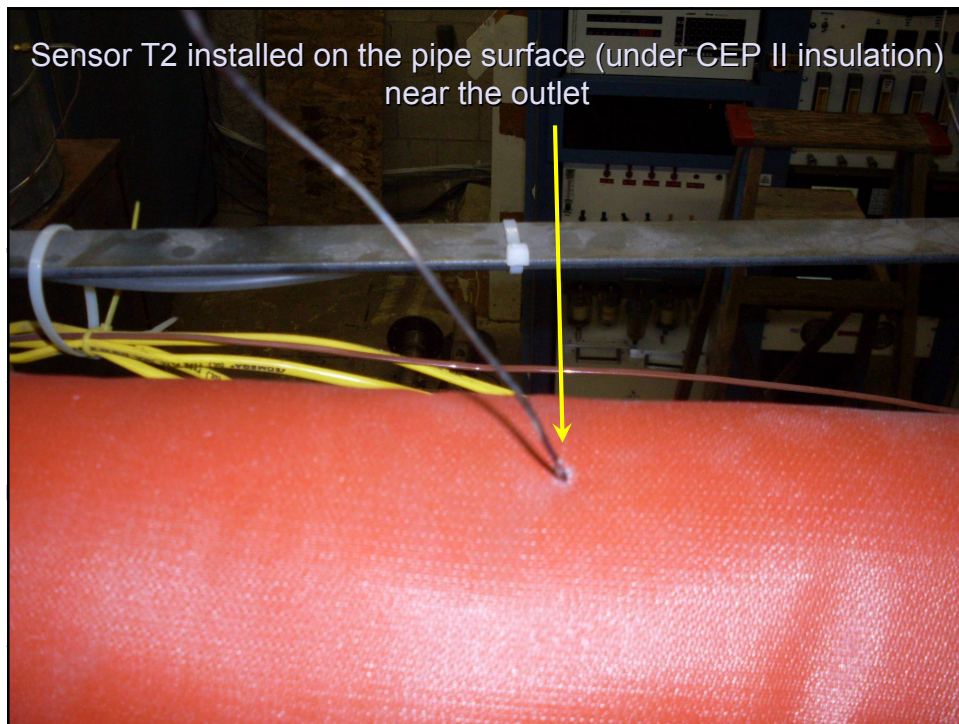
Temperatures were measured in the following steps: with engine off, while engine running with zero load, load increased to 36%, then 72% and back to 36%, zero load, and finally measurement continued for the last stage after engine turned off. The temperature of exhaust gas inside the pipe was measured at Inlet (T5) and outlet (T6) and subtracted to find the heat loss. The temperature of insulation inner layer (T2, hot side) and outer layer (T1, cold side) were measured and subtracted to evaluate heat retention.

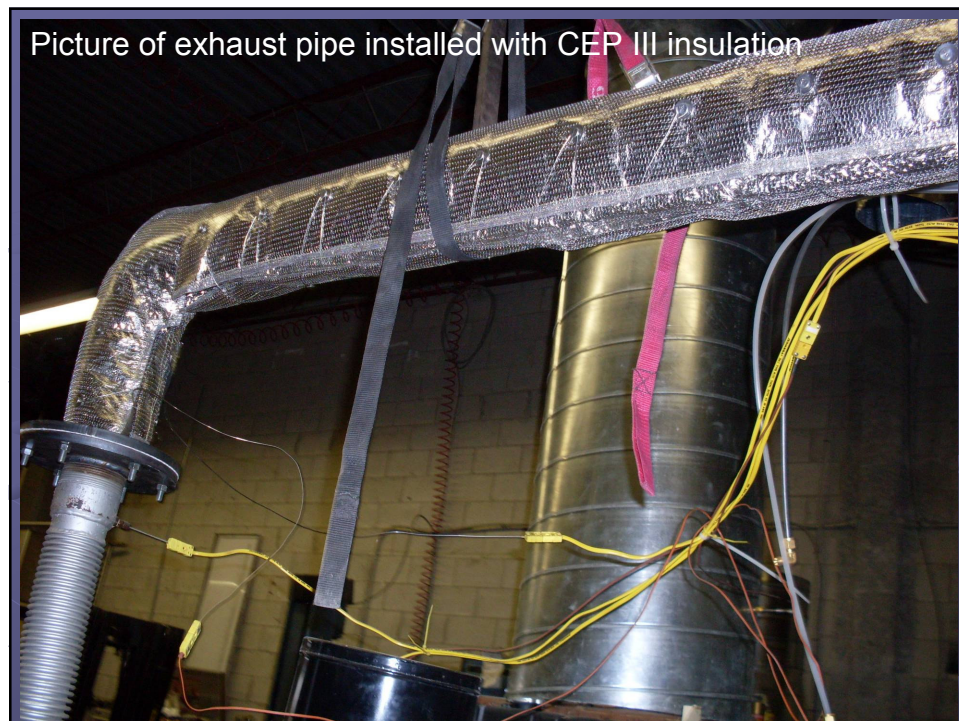
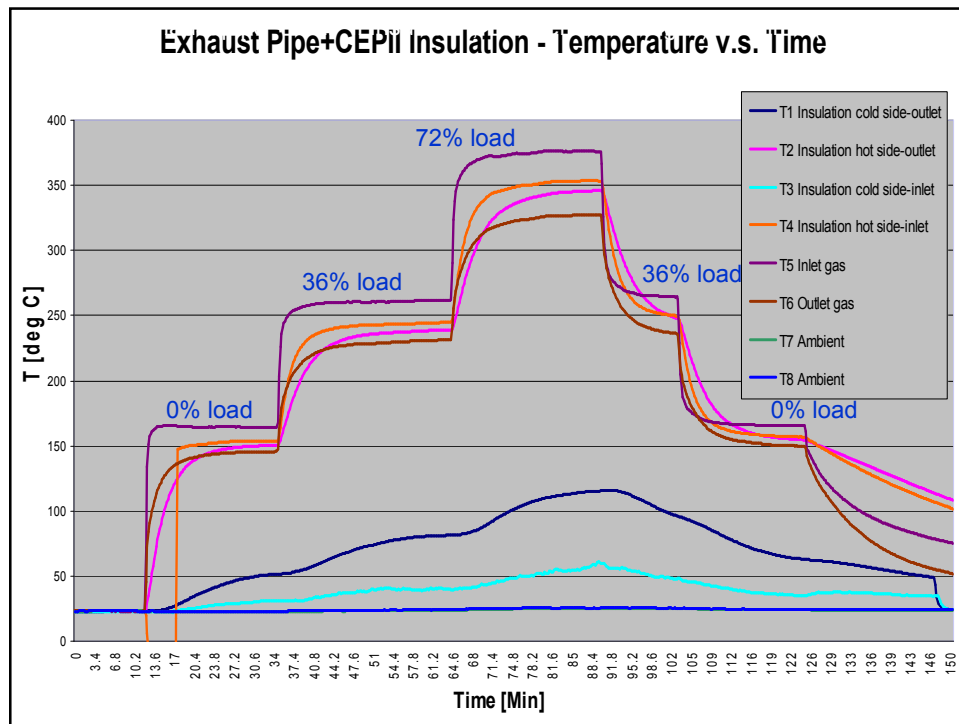


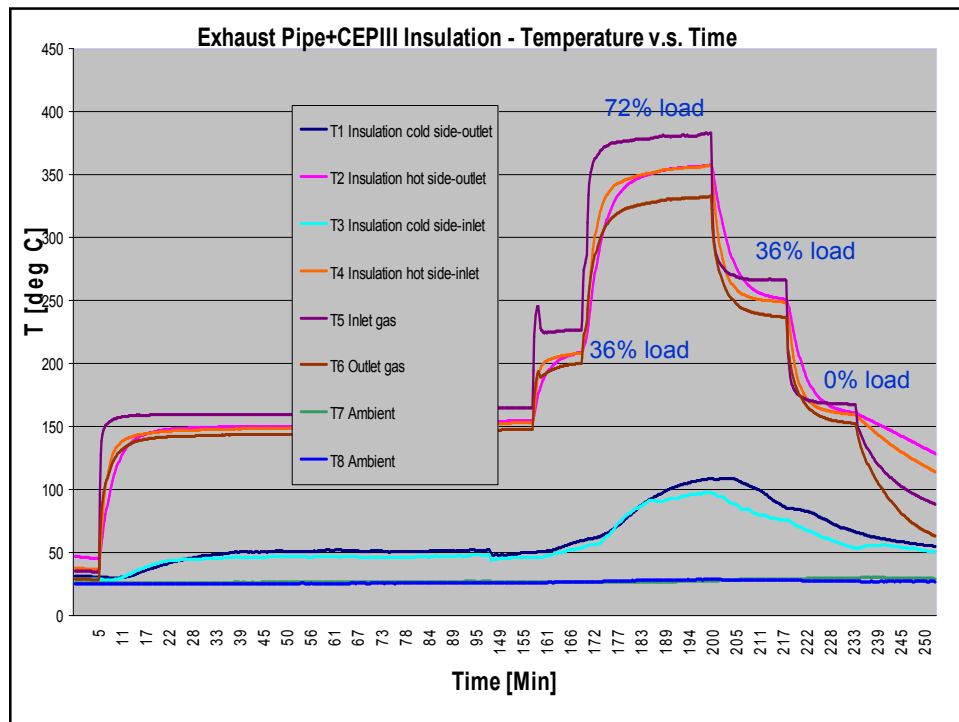


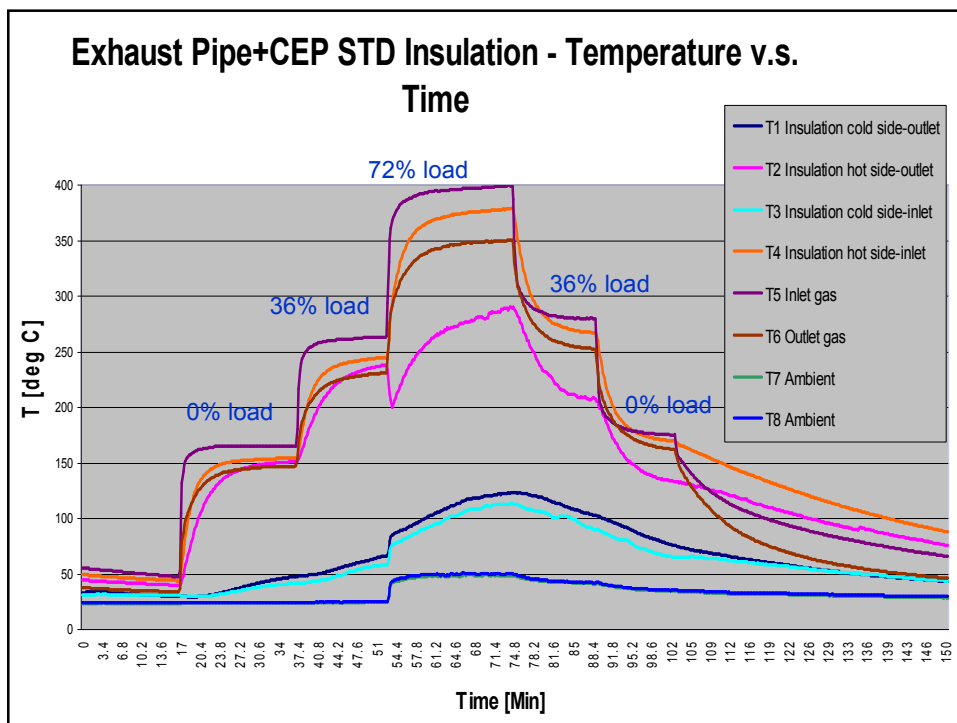
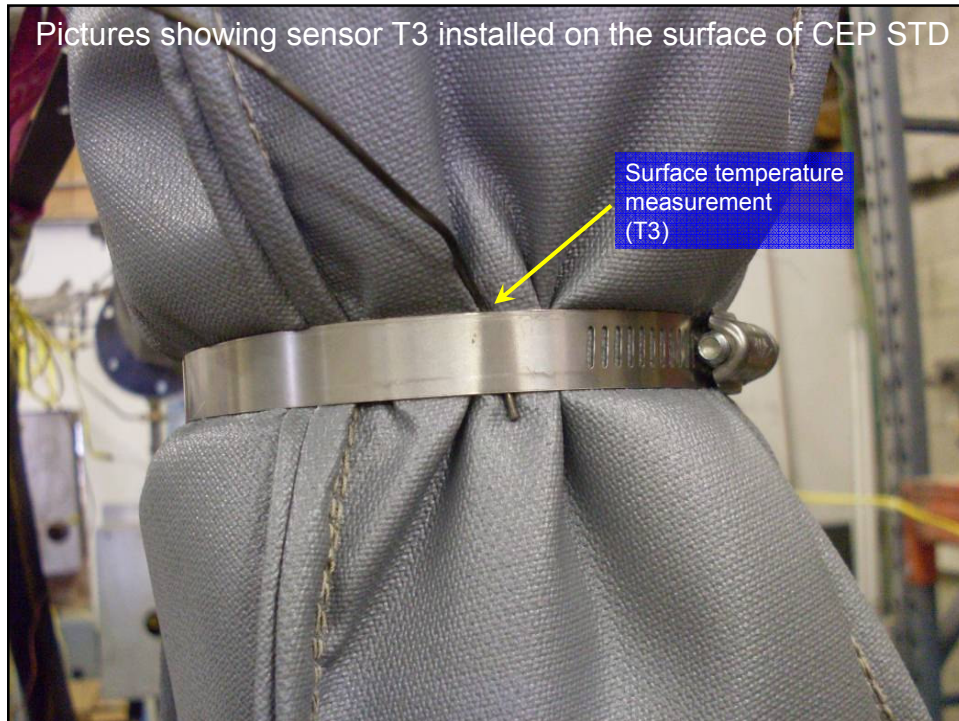


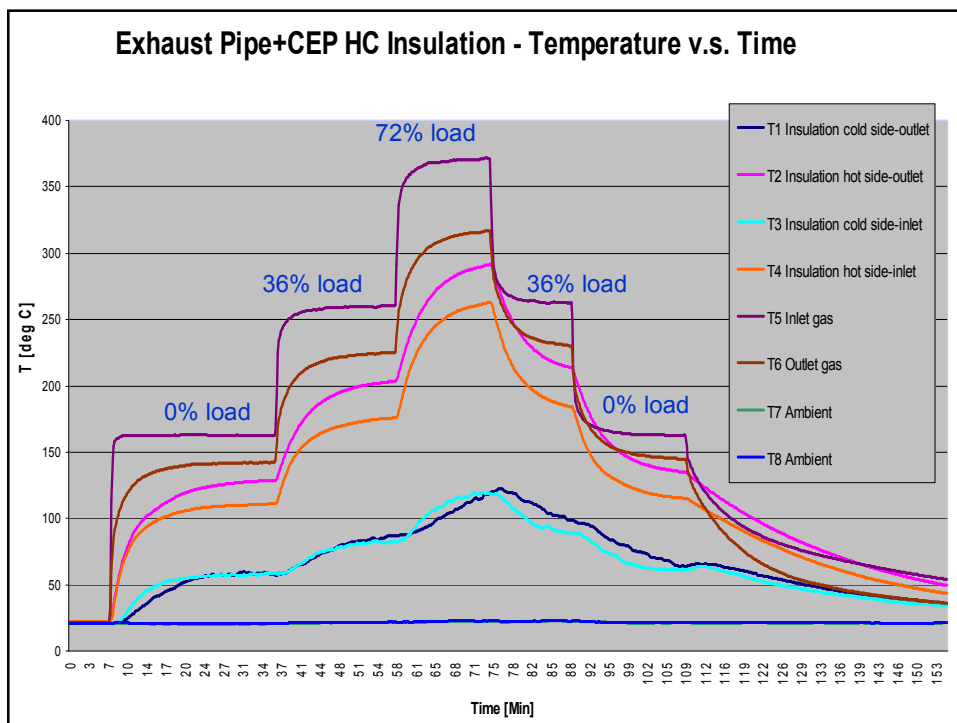
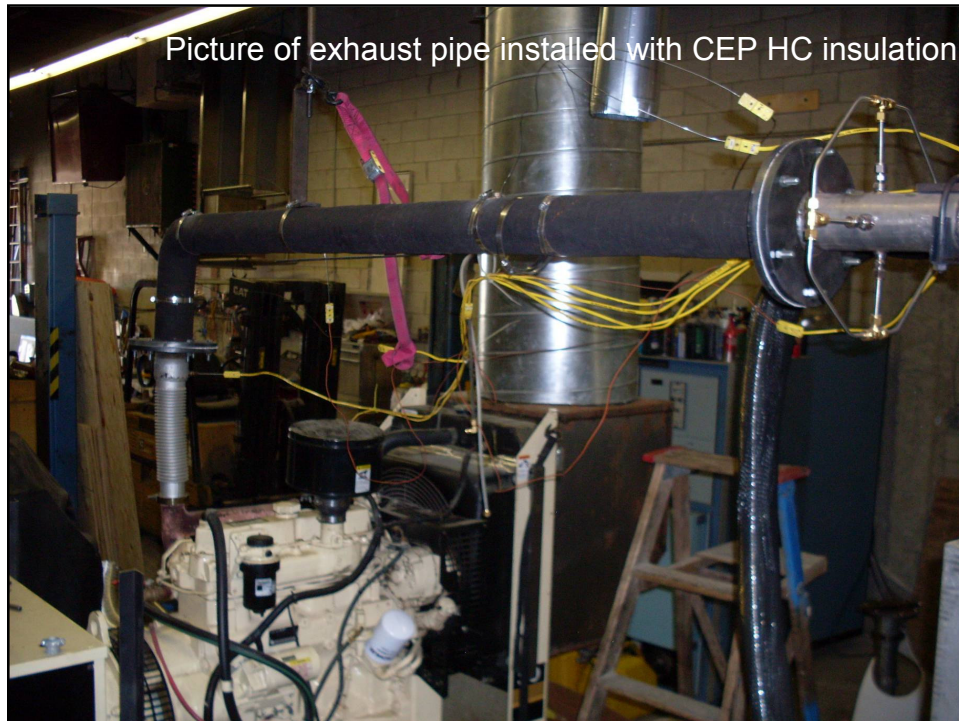








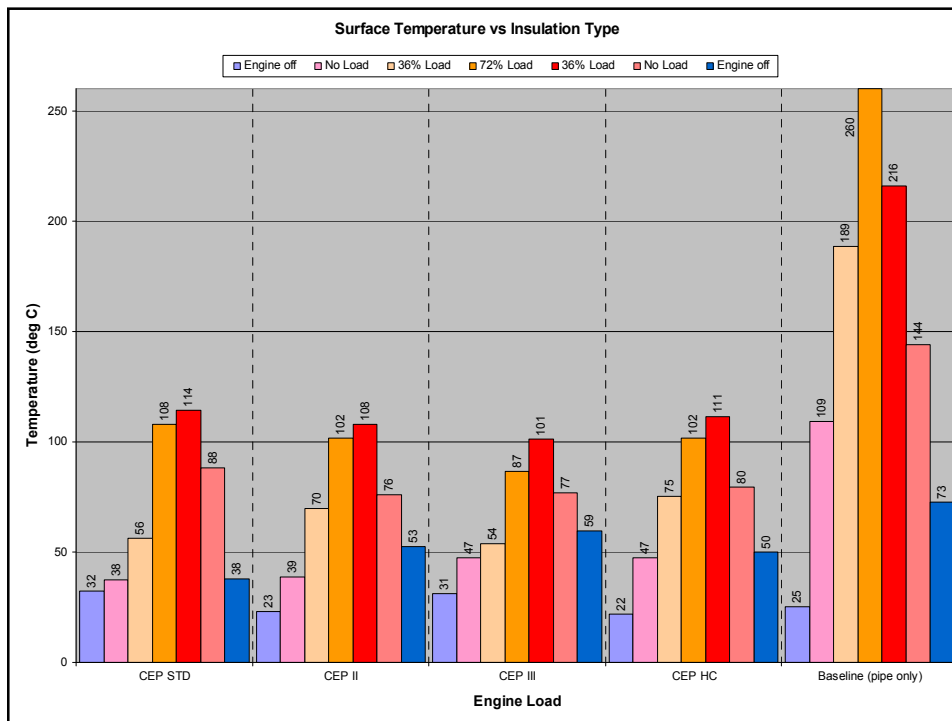


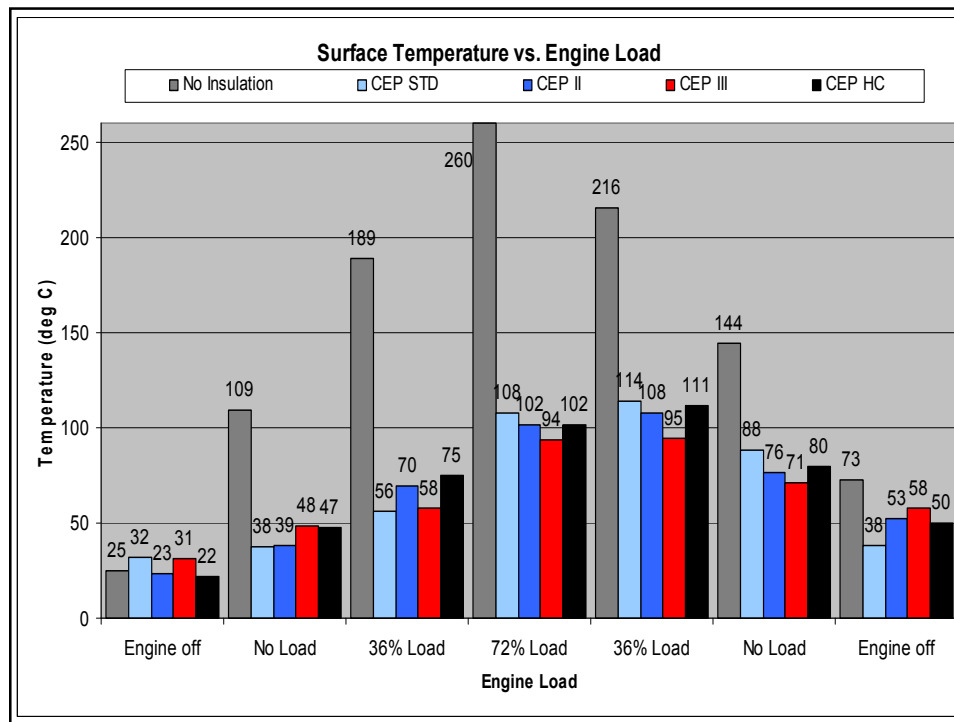


Surface temperature Insulation evaluation

The chart for surface temperature (measured with T1 sensor) vs. insulation type shown on the next two slides. The chart shows that the skin (cold side) temperature of CEP III has the lowest value (101 °C) compare to the other types of insulation (108 to 114 °C). Therefore CEP III is the best insulation in terms of surface temperature and safety. Note that the Values lag behind load change due to insulation resistance. It has a delay in reaching to the maximum temperature during loading of the engine, and it has a delay in cooling off during unloading of the engine, therefore as shown in the chart 36% load shows higher heat than 72%.

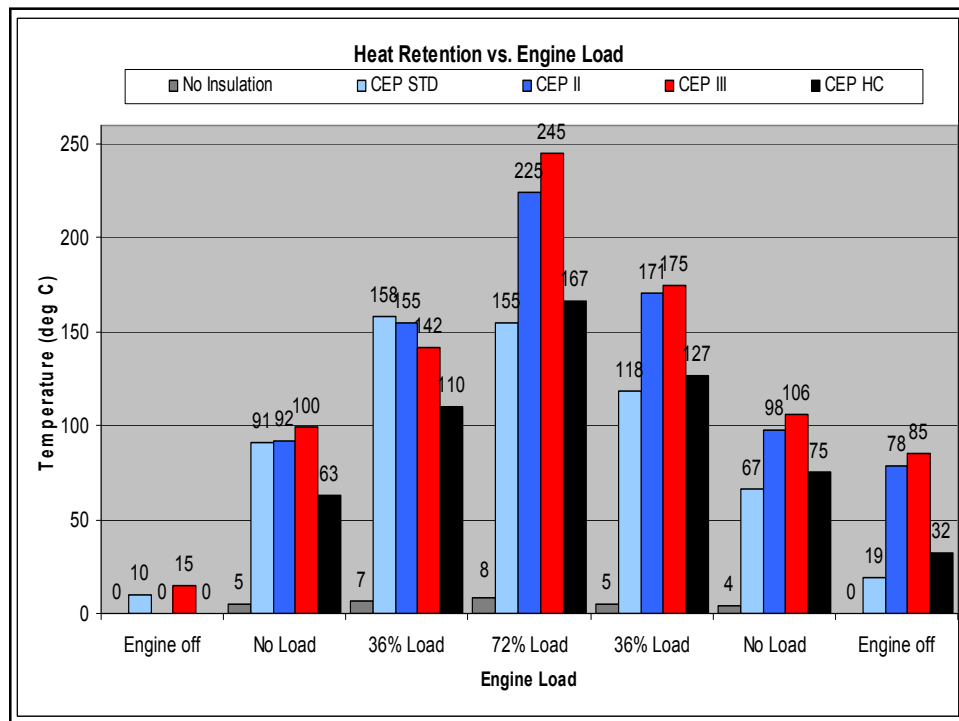
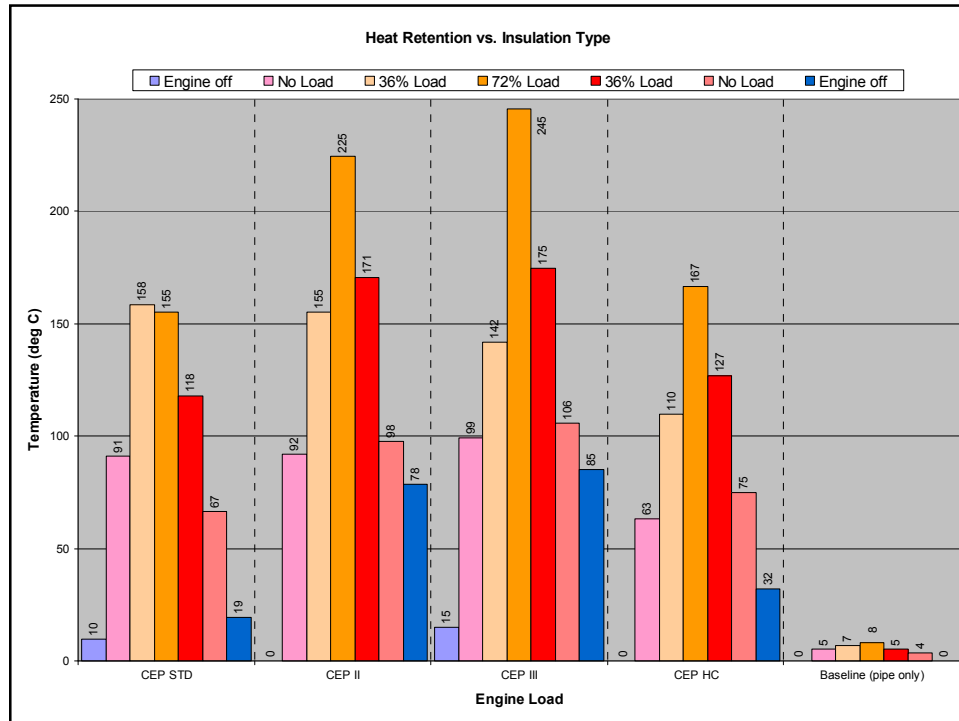
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Insulation Heat Retention Evaluation

On the next two slides, the heat retention was calculated by subtracting T1 from T2. It represents pipe surface temperature (hot side) minus insulation surface (cold side) temperature. As shown in next slide, CEP III has the highest heat retention (245 °C), than CEP II, CEP HC, and CEP STD.

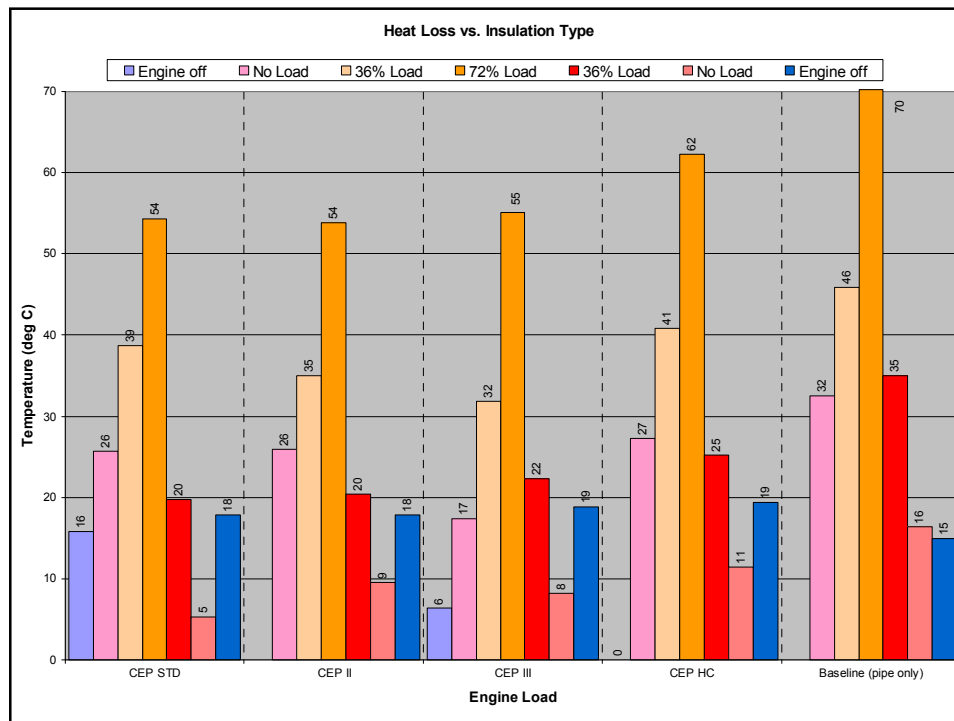


Heat loss inside exhaust pipe

On the next slide the heat lost was calculated by subtracting exhaust gas temperature inside the pipe at inlet from the value at the outlet side, or T5 minus T6.

The lower the value, means lower heat loss, and therefore a better insulation. CEP III, CEP II and CEP STD are almost performed similar and show lower values compare to CEP HC. Therefore all three are acceptable in terms of heat loss prevention.

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Impact Test

In this test 15.87 kg weight was dropped from a height of 4 feet on each insulation while strapped to the exhaust pipe.

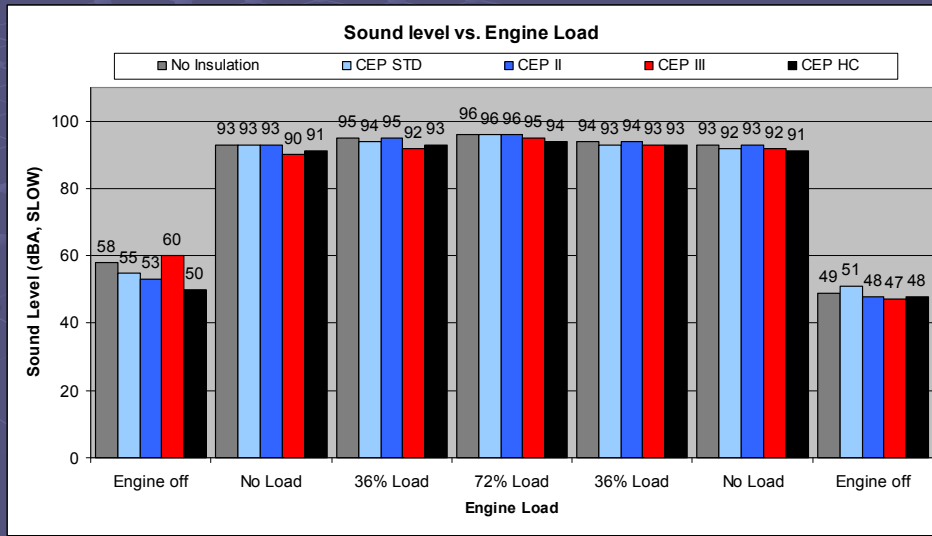
CEP III, CEP II and CEP STD shows no visible damage to the surface of the insulation after the drop test. CEP HC was dented (about 0.25" deep).

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Sound Level Measurement

Sound level measured 26" away from the insulated exhaust pipe. It shows 1-3 dBA Improvement compare to pipe with no insulation. The sound measurement device was exposed to direct engine and other environmental noise.



Oil Absorption Test

- Each insulation was submerged in oil for an hour and weight before and after, the result is shown as % gain over the original weight:
- CEP STD 75% (highest oil absorption)
- CEP II 71%
- CEP III 64%
- CEP HC 33% (lowest oil absorption)