SITE VISIT REPORT			
CUSTOMER:	WorldKlass	**DATE:**	4/10/2014
VESSEL/PLANT:	Engine Systems	**WORK ORDER #:**	N/A
LOCATION:	Tucker, GA	**TECHNICIAN:**	Peter in 't Zandt
CONTACT:	Bill Grovatt	**ENGINE MAKE/MODEL:**	Cummins 6BT5.9-D(M)
CONTACT PHONE:	610-909-7142	**GOV./CTRL TYPE:**	N/A
CONTACT EMAIL:	bgrovatt@worldklass.com	**GOV. PART NO:**	
PURCHASE ORDER#:	N/A	**GOV. SERIAL NO:**	

People involved in this trip:
Bill Grovatt – WorldKlass
Alan Kline – WorldKlass
Albert Wey – Aldi Far-IR Products, Inc.
Tom Frawley – Thomas Frawley Consulting, LLC
Bo Mikkelsen – Engine Technology Support, Inc.
Keith Fulp – Keith Fulp Motorsports
Peter in ‘t Zandt – Governor Control Systems, Inc.

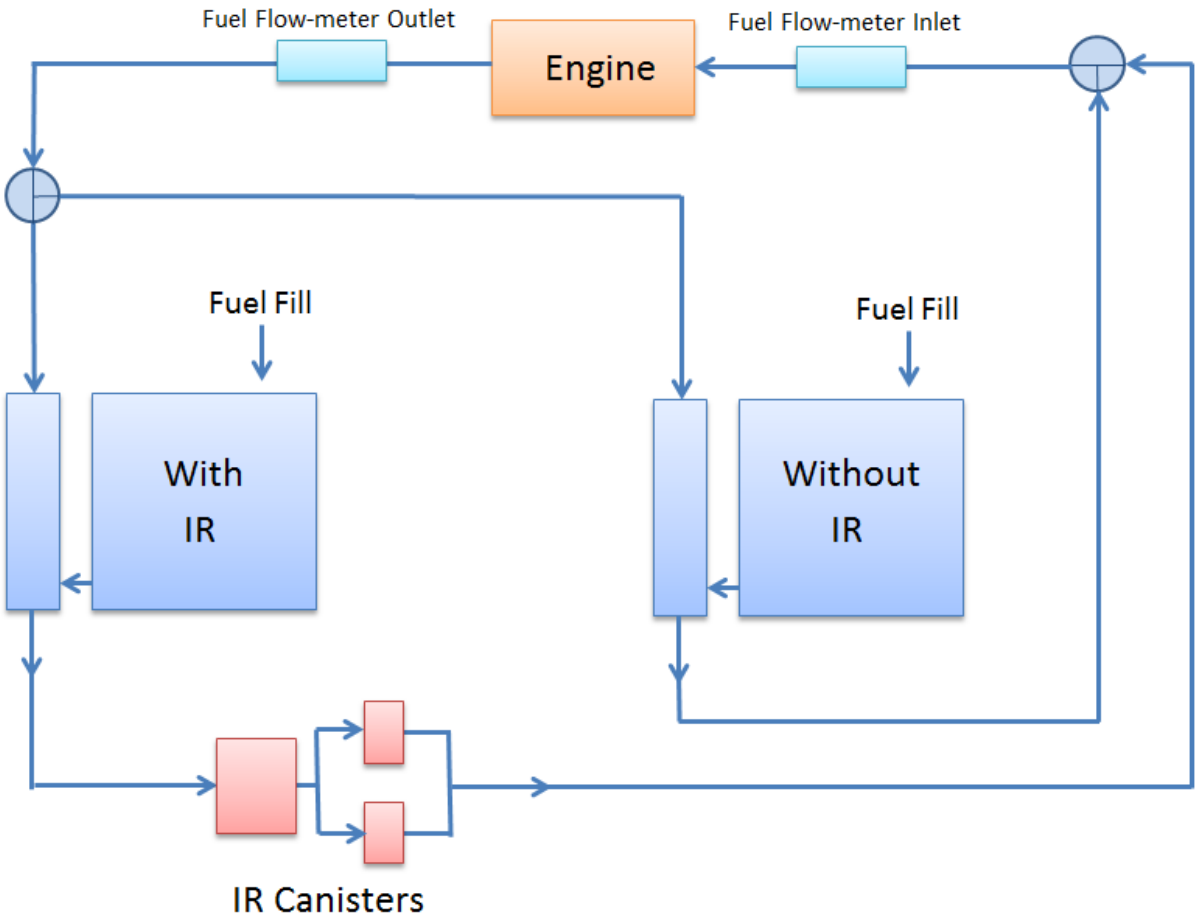
Purpose of visit:
Verify the difference in fuel consumption and emissions on a Cummins 5.9 liter 6-cylinder diesel engine connected to a dyno load-bank whilst running on regular on-highway diesel fuel, and on-highway diesel fuel with the IR (infra-red) induced diesel fuel.
This IR system works on the principle that the fuel passes through canisters that have a certain type of ceramics inside that emit photons when fuel is passed them (fuel has to be above 85 F for this to work effectively). These photons change something on molecular level on the hydro-carbon molecules in the fuel which in a recip internal combustion engine causes the fuel to burn more evenly, more effectively and earlier (faster) compared to non IR induced fuel. This results in using less mass of fuel for the same power output.
A major side effect (besides the fuel savings) is that the particles in the exhaust gas emissions go down drastically so the visible smoke is reduced significantly.
Another advantage is because of the better combustion and less particulates in the exhaust, the lube oil of the engine remains much cleaner and according to WorldKlass on some applications the end user was able to extend the oil level by 50% to 100%, creating a huge savings in lube oil cost.

Status on arrival:
Engine running at 1000 rpm on regular on-highway diesel fuel with approximately 25% load.

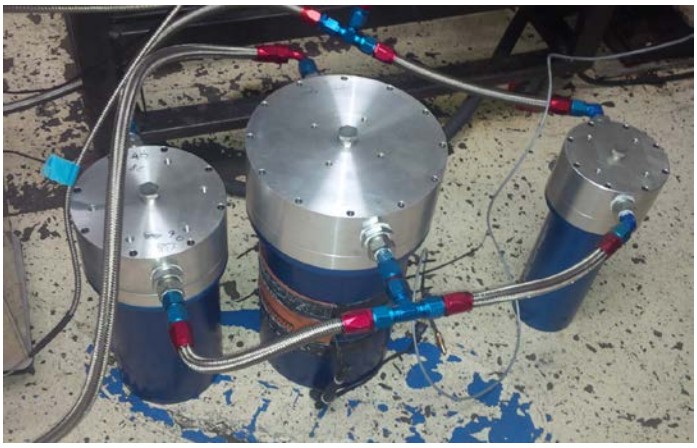
Report:

Wednesday, April 9, 2014:

Traveled to Tucker, GA and went to Engine Systems. Met with all people involved and witnessed the first test where the engine was running on low load, both with and without IR fuel for 2 hours on each fuel.
In the test-stand a 6-cylinder Cummins 6BT5.9-D(M) engine was used, running on standard on-highway diesel fuel.
Shown below is a flow-chart of how the fuel system set-up was done inside the dyno test room:



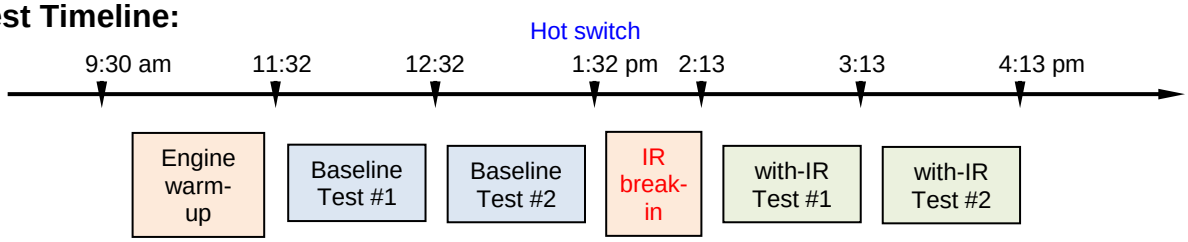
With the above system we can switch over from regular diesel fuel to IR induced diesel fuel without changing the speed or the load on the engine to make both tests identical without changing any external factors except for the type of fuel used.



The 2 tanks of each fuel system (larger storage tank and smaller recirculation tank) are both set on top of an accurate digital scale which is monitored constantly to measure the amount of fuel used each hour.
At regular intervals a snapshot of the emissions in the exhaust system was recorded with an Ecom J2KNpro emission measuring device. And real-time data for speed, torque, power, fuel-flow and temperatures was displayed on an HMI:

We first ran the engine at 1000 rpm at 22.5 HP without IR to create a baseline of the fuel-consumption.
After running like this for 2 hours we switched over to the IR system (without stopping or unloading the engine to keep the amount of variables to a minimum).
We than let the system settle with IR for about 45 minutes before started the 2 hour measured run on IR.

Test Timeline:



Test Results:

Test	Baseline #1	Baseline #2	With-IR #1	With-IR #2
Oil Temp, ºF	141	142	142	143
Water Temp, ºF	169	168	169	169
Fuel Temp, ºF	85	87	81*	82*
Power, Hp	22.5	22.6	22.5	22.4
Fuel, lb/hr	**8.36**	**8.44**	**8.17**	**8.04**
BSFC, lb/bHphr	0.3716	0.3735	0.3631	0.3589
Change, %	**baseline**	**0.0 %**	**- 2.3 %**	**- 3.4 %**
O_2 %	15.3 %	15.3 %	15.4 %	15.5 %
CO_2 %	4.2 %	4.2 %	4.1 %	4.0 %

*note: actual fuel temperature may be higher

Fuel rate, lb/hr

Fuel efficiency Improvement, %

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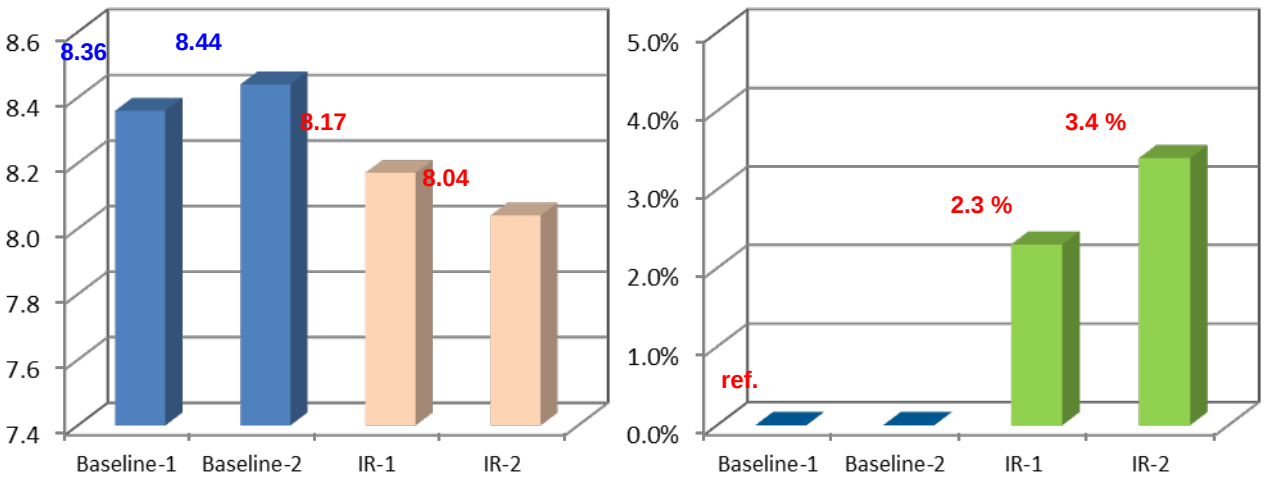

It shows a measureable improvement in fuel-efficiency when using the IR system. In this test the efficiency keeps improving the longer the system is running on IR. This is what we expected as it takes a fair amount of time before the whole system is saturated with IR photons at which point we get the maximum benefit.
Due to time constraints we did not have chance to run the system longer than 2 hours on each fuel but it is very likely that the fuel-efficiency would have improved slightly more. (This is what WorldKlass has witnessed on other applications in the field where the system is running for many days).

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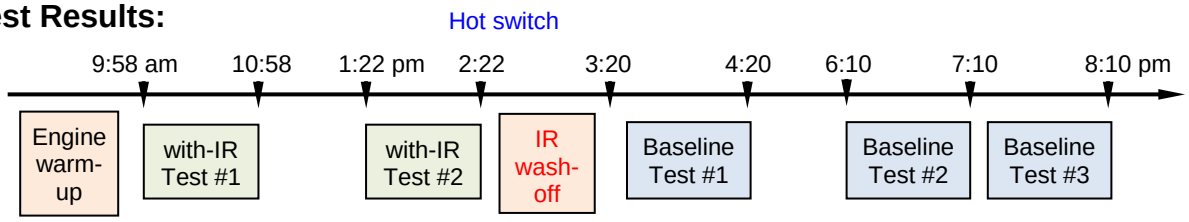
Thursday, April 10, 2014:

We first ran the engine at 1500 rpm at 80 HP with IR to create a baseline of the fuel-consumption. The reason we started WITH IR this time is because the system was still full of IR fuel from the test yesterday.

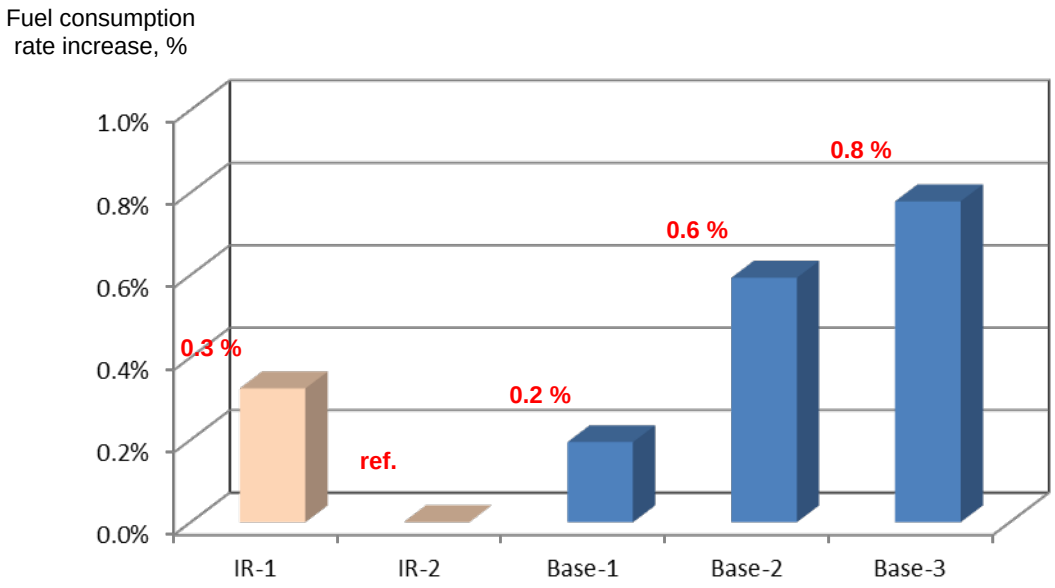
After running with IR for 2 hours we switched over to the non-IR fuel (without stopping or unloading the engine to keep the amount of variables to a minimum).

We than let the system settle without IR for about an hour before started the 2 hour measured run on regular fuel.

Test Results:



Test	With-IR #1	With-IR #2	Baseline #1	Baseline #2	Baseline #3
Oil Temp, ºF	147	151	155	154	154
Water Temp, ºF	176	175	178	178	179
Fuel Temp, ºF	75*	81*	82	88	90
Power, Hp	72.9	73.2	72.9	72.8	73.2
Fuel, lb/hr	**23.10**	**23.12**	**23.07**	**23.13**	**23.30**
BSFC, lb/bHphr	0.3169	0.3158	0.3165	0.3177	0.3183
Change, %	**0.3%**	**0.0%**	**0.2%**	**0.6%**	**0.8%**
O_2 %	11.5 %	11.5 %	11.4 %	11.4 %	11.4 %
CO_2 %	7.0 %	7.0 %	7.0 %	7.0 %	7.0 %



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The test results confirmed what we saw yesterday (but in reverse order). The fuel efficiency was decreasing when we switched back to regular fuel.
The test yesterday was at around 25% engine load (at 1000 rpm) and today's test was at 80% engine load (at 1500 rpm).
It is clear that at lower loads the fuel efficiency difference is greater than at higher loads. This is most likely due to the fact the engine and turbo-charger is designed to run at high load and at that point the fuel-efficiency is better than at low load.

Friday, April 11, 2014:
Traveled back to Florida.

Conclusion(s):
From GCS' point of view the test was completed successfully as we have proven data that the fuel efficiency increases with the use of IR induced fuel.
For us to go to market and try and win our bigger customers with large engine we need some hard data from Royal Utilities in St.Kitts. They have 2 Wärtsilä 200 engines (2.2 MW each) and have had the system installed for several months now. They have fuel metering installed and have data from before the system was installed. We are waiting for new data from after the system was installed so we can compare the numbers.
It is important to understand that for any customer we sell this to, they MUST have an accurate fuel measuring system as that is our only prove of fuel-efficiency increase. This means for customers that don't have this in place yet we have to sell our KRAL system as well.

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