



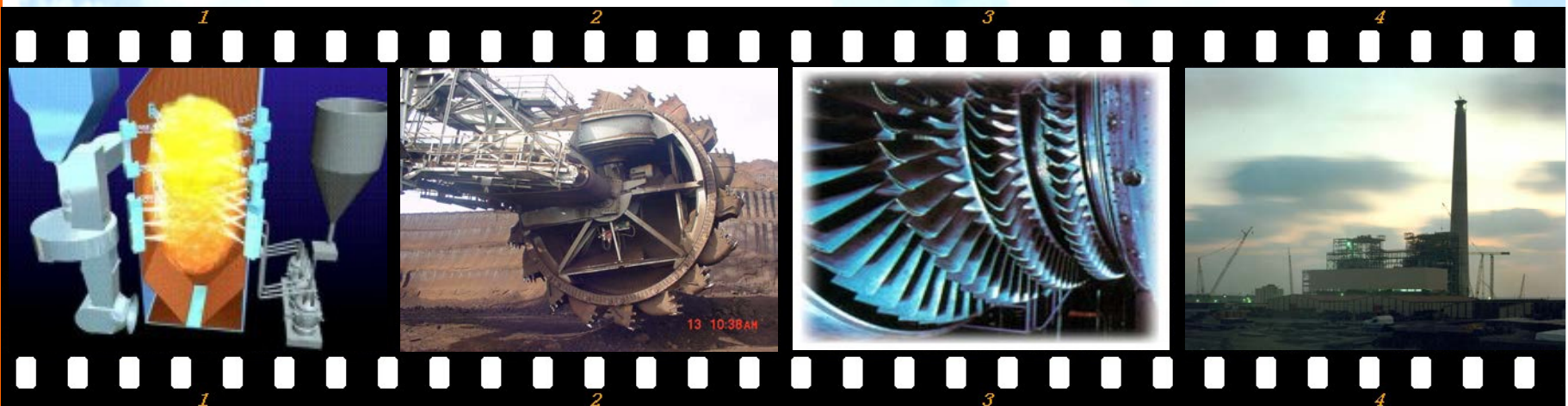
Methanol As Low Cost Alternative Fuel For Emission Reduction In Gas Turbines and Utilities Boilers

IEC and Dor Chemicals

Jan 13th , 2013

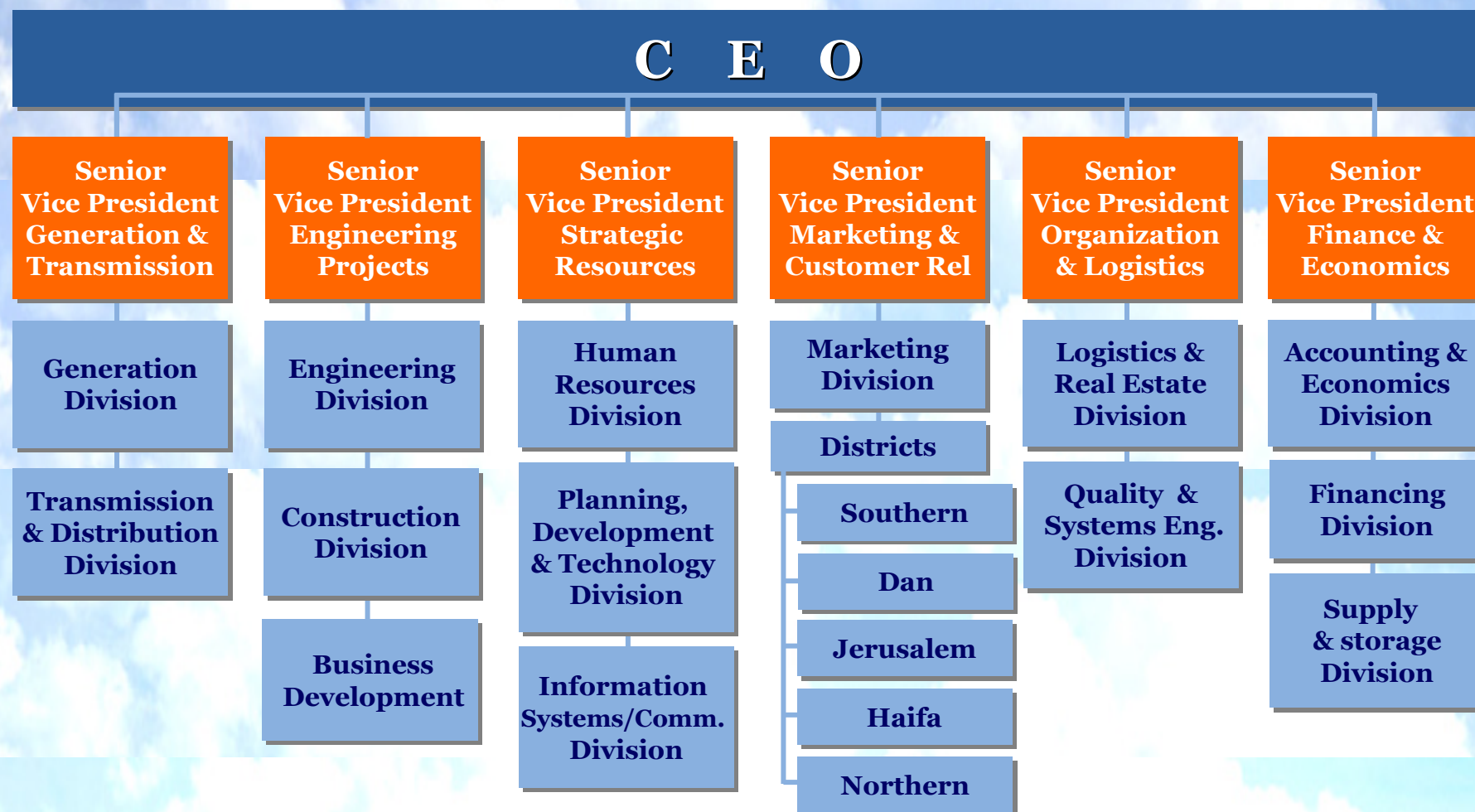
**Weizman Institute of Science, Rehovot,
Israel**

The Israel Electric Corp.





The Israel Electric Corp. – Organization Chart





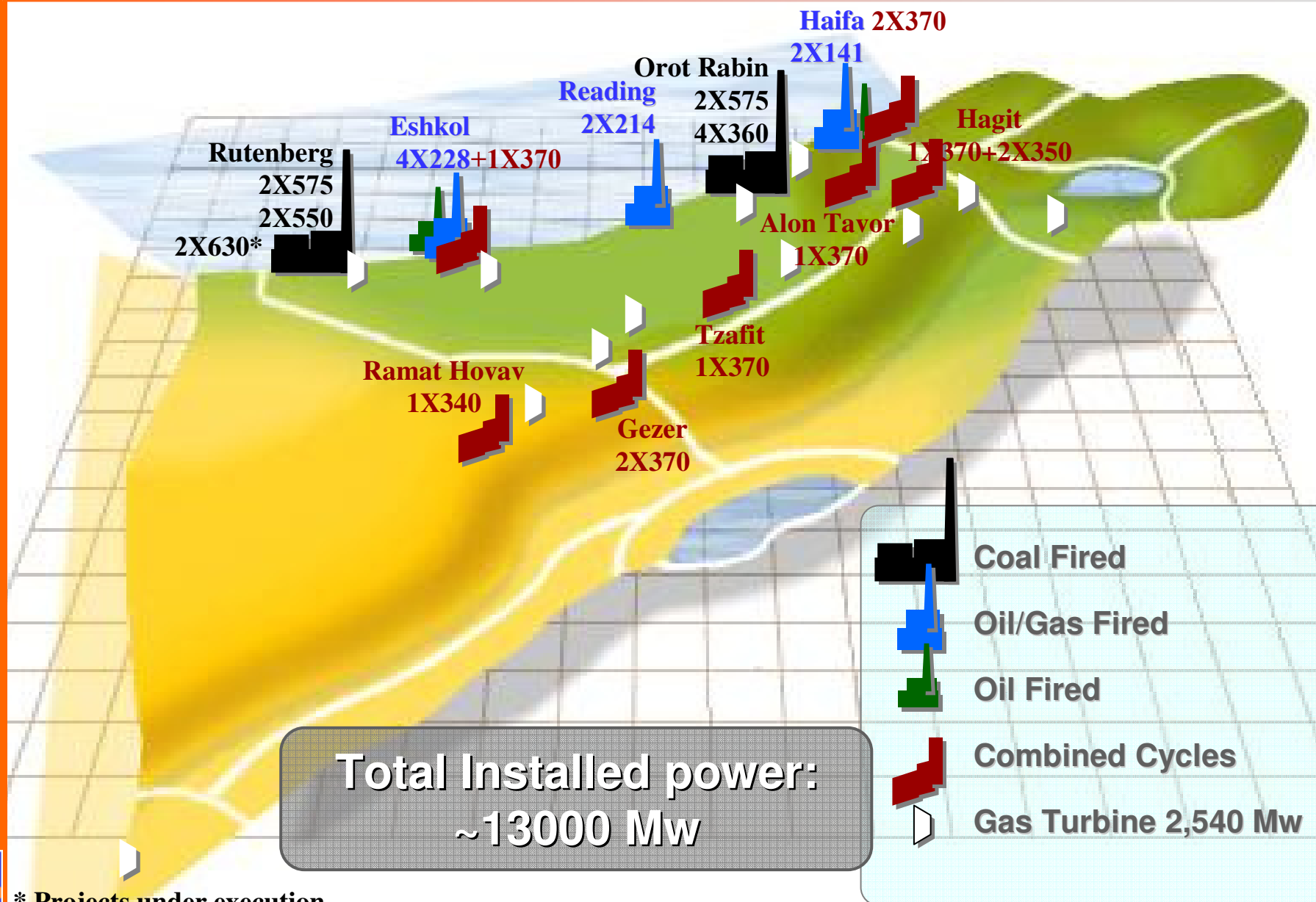
IEC's Engineering Project Group Organization

Engineering Projects Group





The Israel Electric Corp. Power Plants





The Israel Electric Corp. – Fuel Burned

- Bituminous coal – very wide range of properties
- Sub-bituminous coal – Low Sulfur
- Heavy Fuel Oil#6
- Light fuel Oil#2
- Natural Gas
- **Methanol**
- Preparation for Biomass (Biocoal) and Coal co-firing
- Preparation for Coal and Sewage co-firing
- Oil Shale





The Israel Electric Corp. – Emission Reduction activity

- **Low NOx Firing System Implementation**
- **Post Combustion Treatment:**
 - **SCR installation for NOx Reduction**
 - **FGD installation for SO₂ Reduction**
 - **ESP for ash reduction**





Outline

Methanol Fuel properties

- **Chemical Formula CH_3OH**
- **Molecular weight 32.04**
- **Flash point 12 C (to 41 C)**
- **Auto ignition temperature 464 C**
- **Combustion (Adiabatic) temperature 2045 C**
- **Low heating value 4777 kcal/kg**
- **Density 793 kg/ M^3 at 30 C**



Overview

- **Methanol is an attractive future fuel for utility boilers and gas turbine engines.**

Methanol can achieve:

- 1. Lower NO_x emissions due to the lower flame temperature and no FBN.**
- 2. Since methanol has no sulfur there are no SO₂ emissions.**
- 3. The clean burning characteristics of methanol are expected to lead to clean heat surfaces and lower maintenance than with HFO or even with LFO.**
- 4. Relative to NG and FO, methanol can achieve higher power output due to higher mass flow in GT engines.**





Mechanism of NO_x Emission Formation

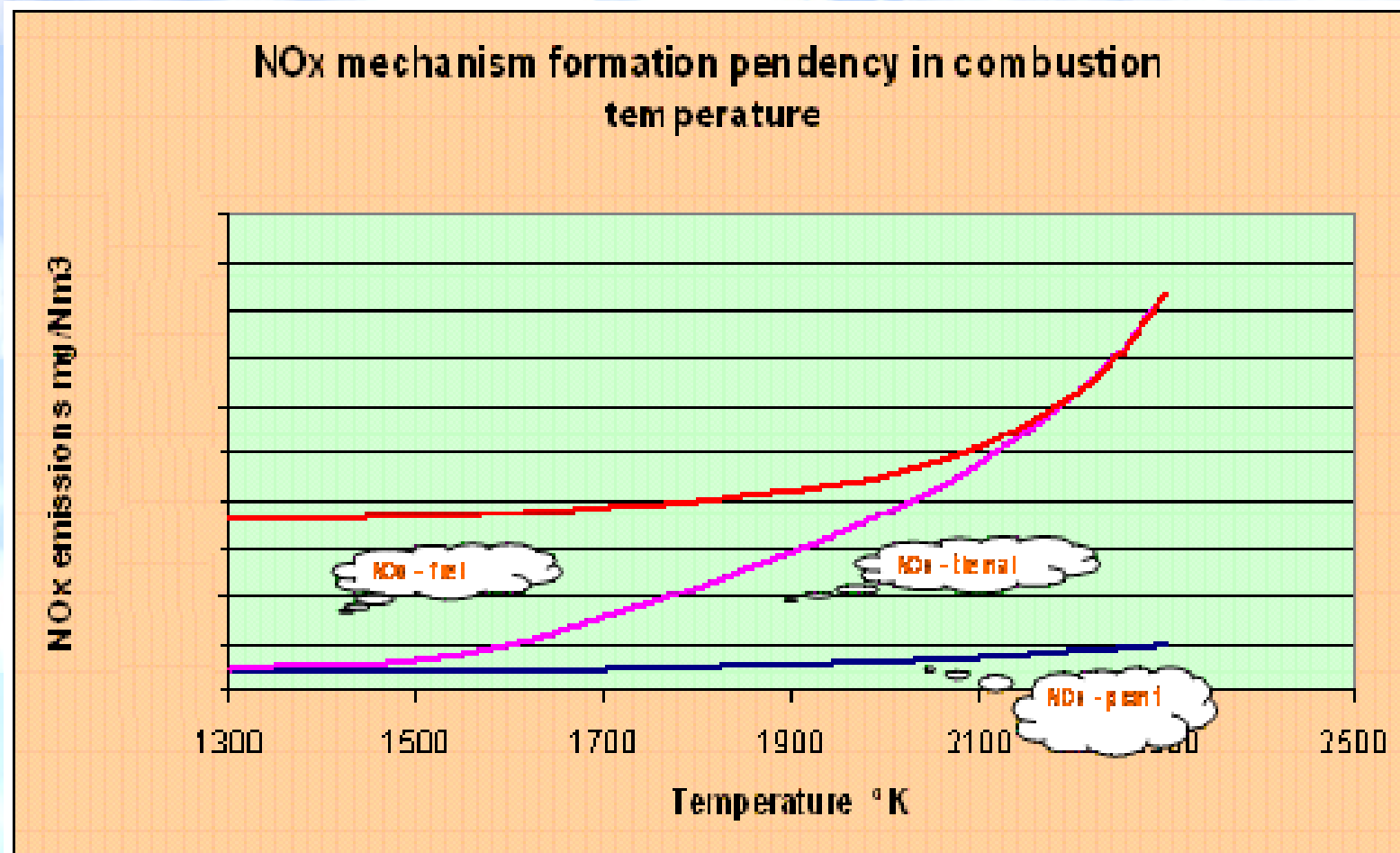
There are three known mechanism of NO_x formation

- Thermal NO_x
- Fuel NO_x
- Prompt NO_x

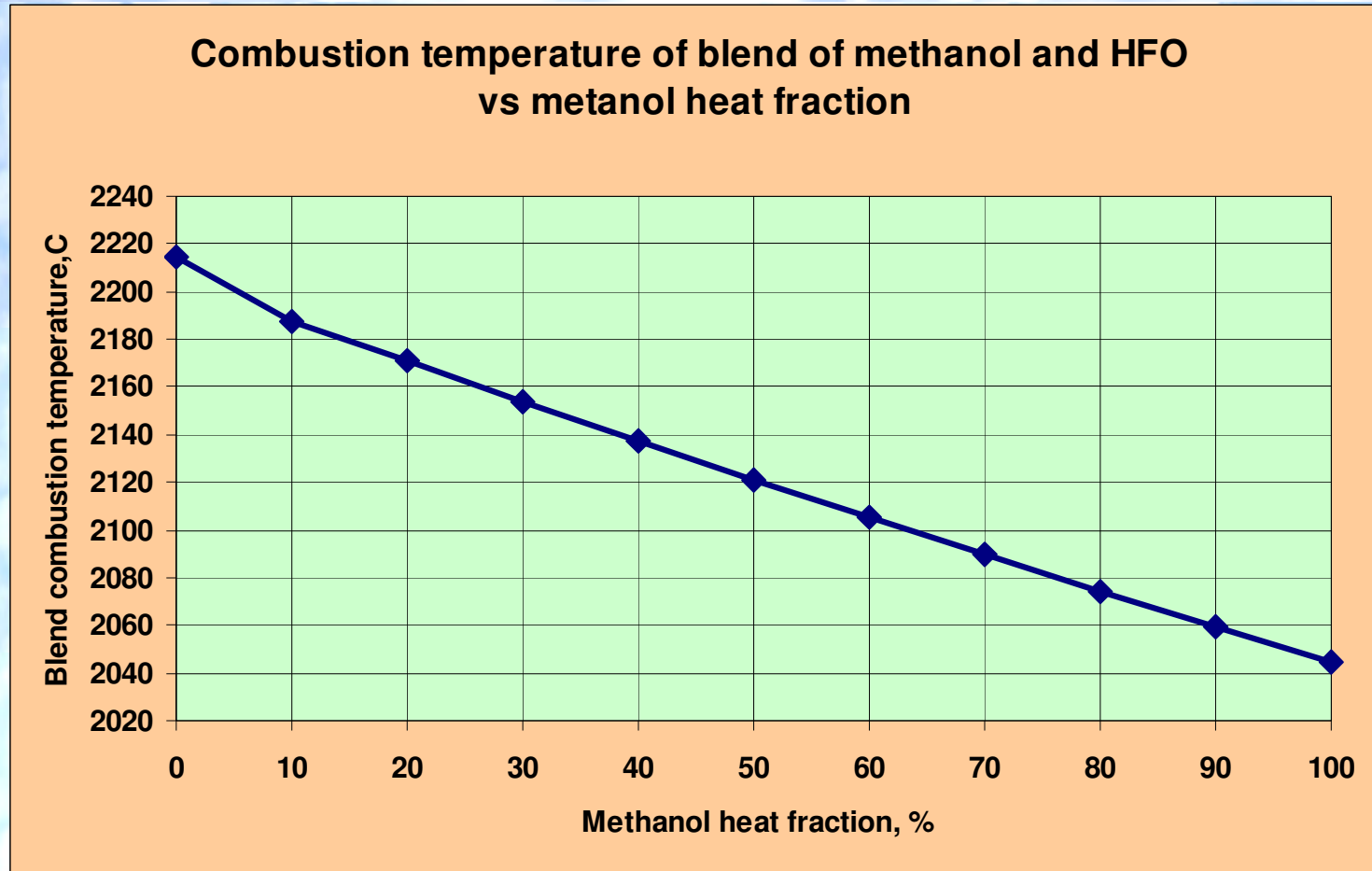




NO_x formation mechanism



Combustion temperature of blend of methanol and HFO





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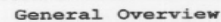
Methanol and HFO Co-Firing At Large Utility Boiler of 140 Mw Unit



Haifa Power Plant Site

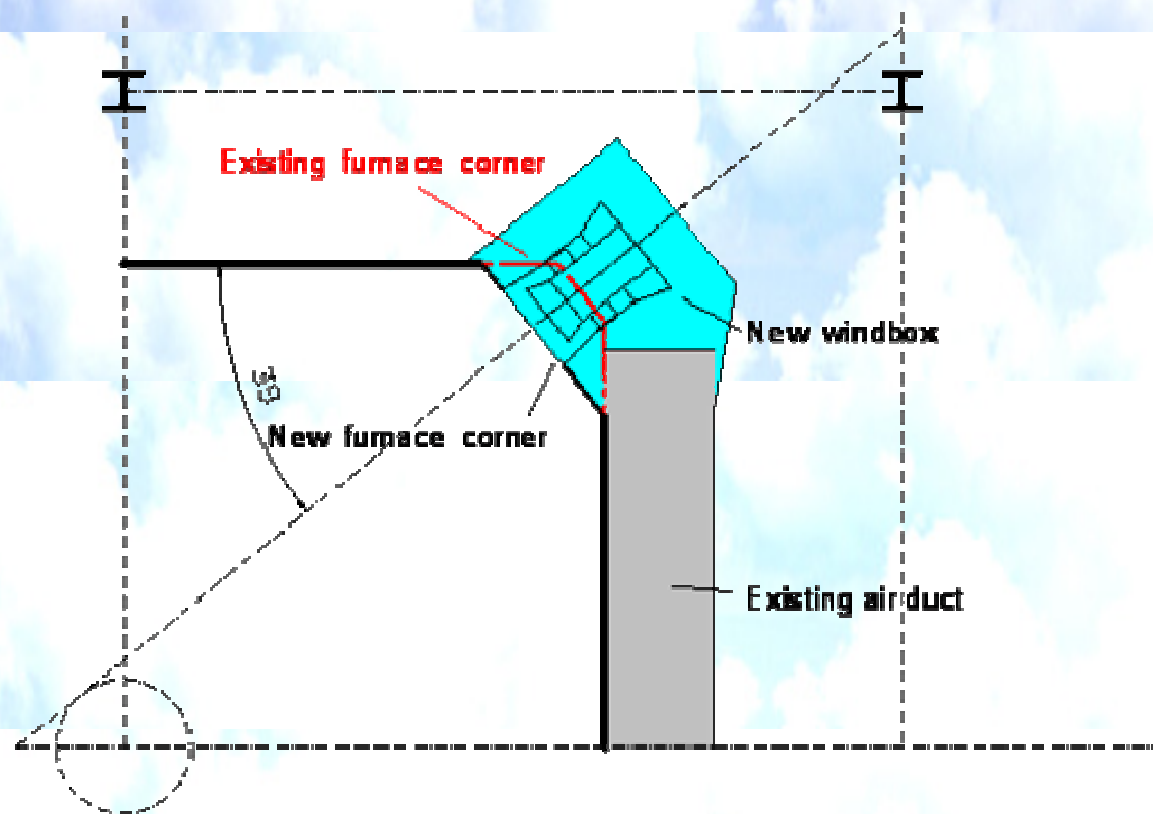


Boiler Low Emissions Retrofit and Conversion to Natural Gas Firing of Haifa "C" Power Station Units 3 + 4



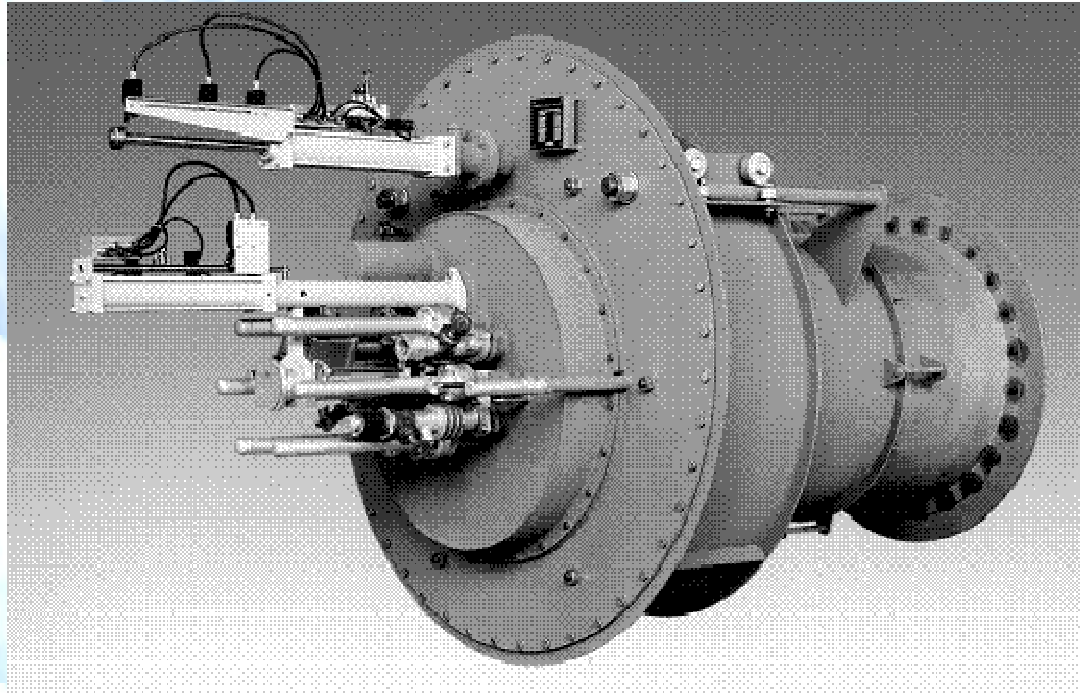
Primary measures implementation

Furnace crosssection

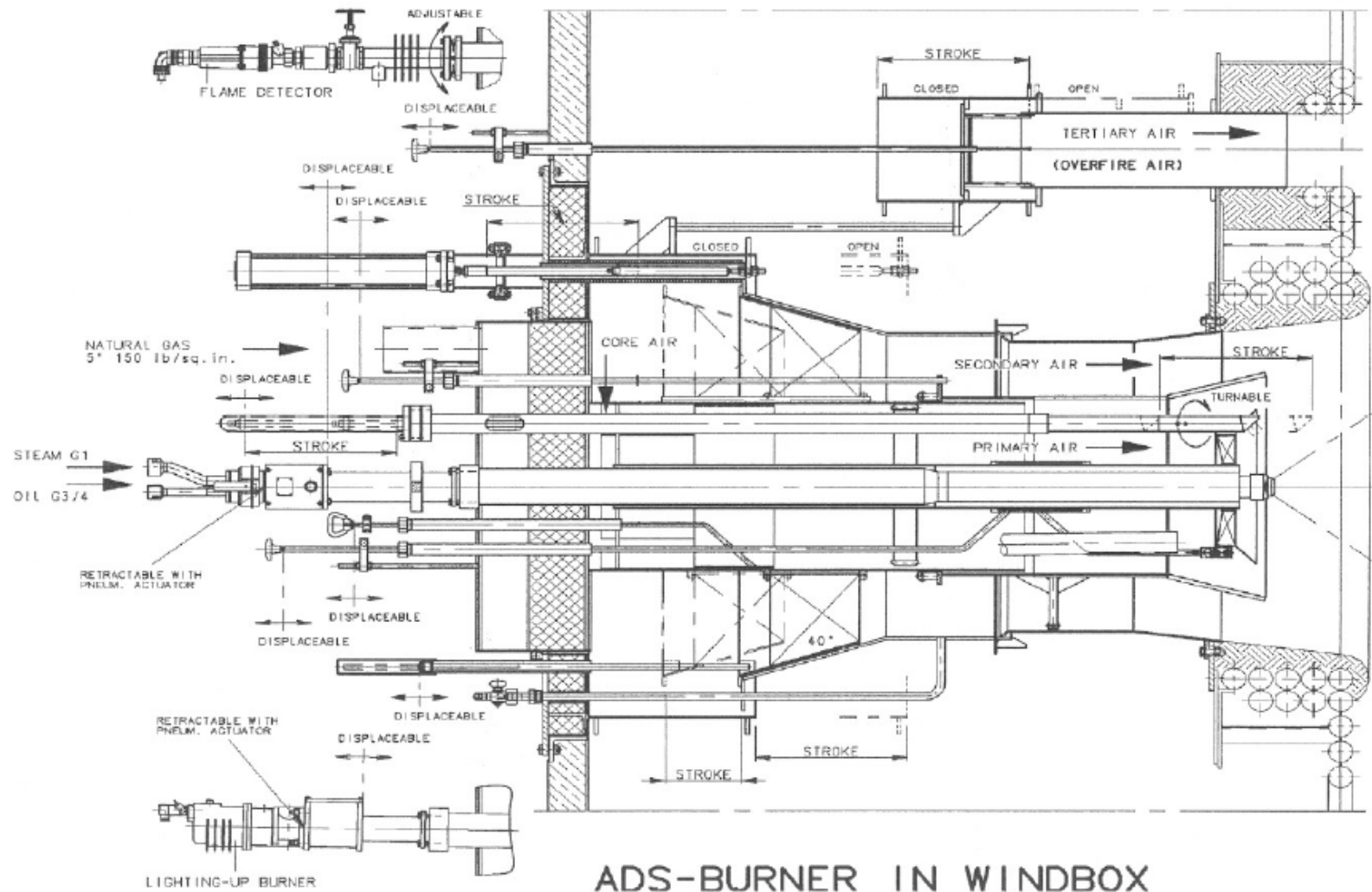




Primary measures implementation Burner – General view

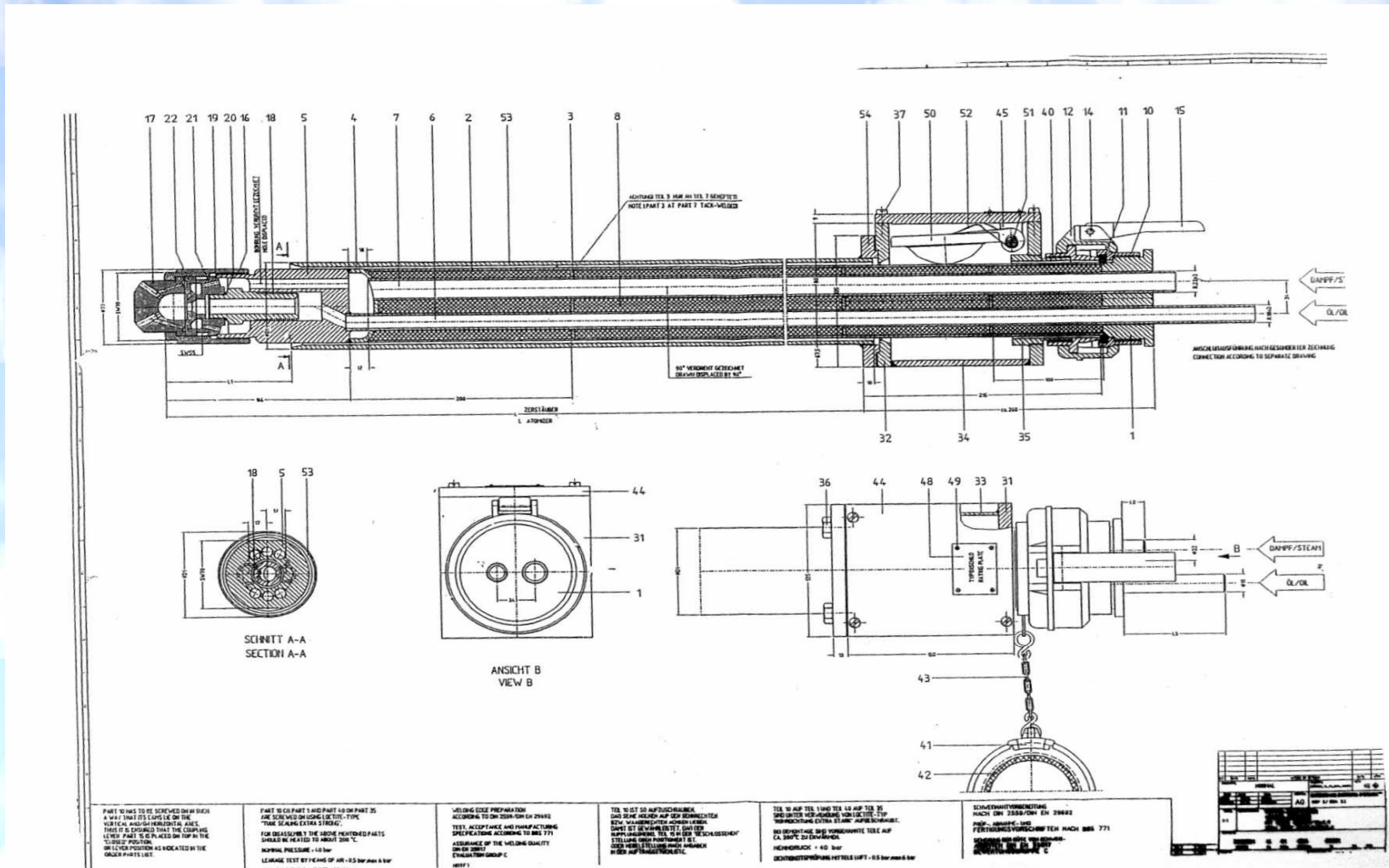


Primary measures implementation Burner – Design





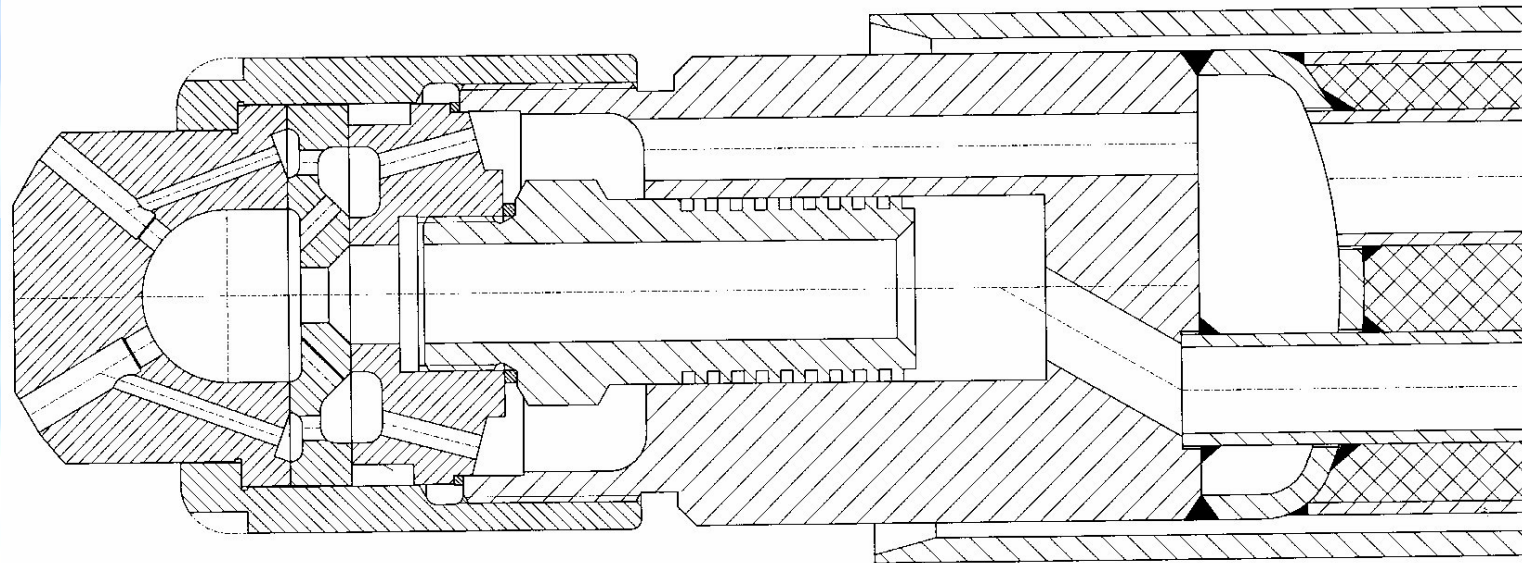
Primary measures implementation HFO Atomizer – General view





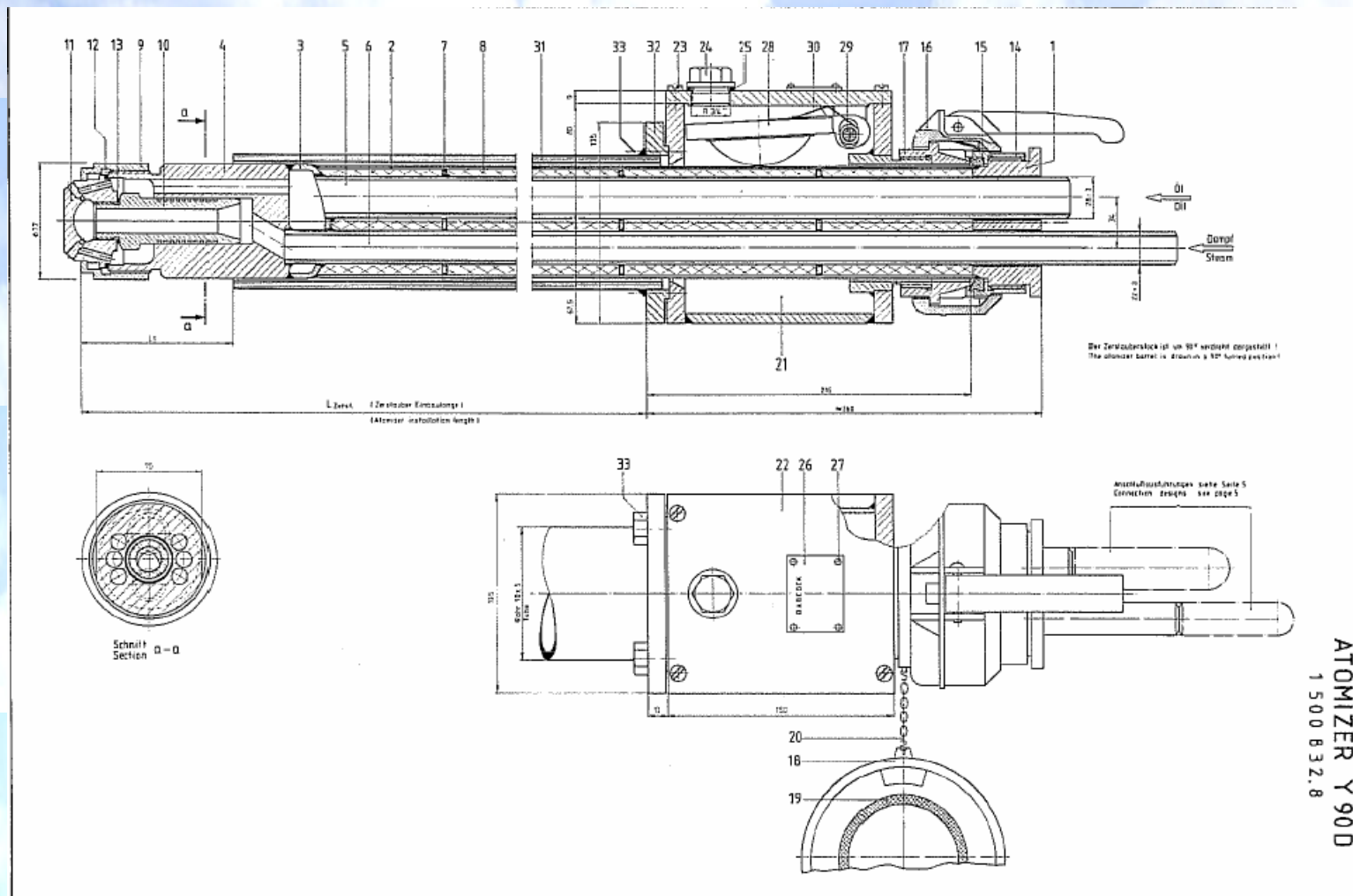
Primary measures implementation

HFO Atomizer – General view



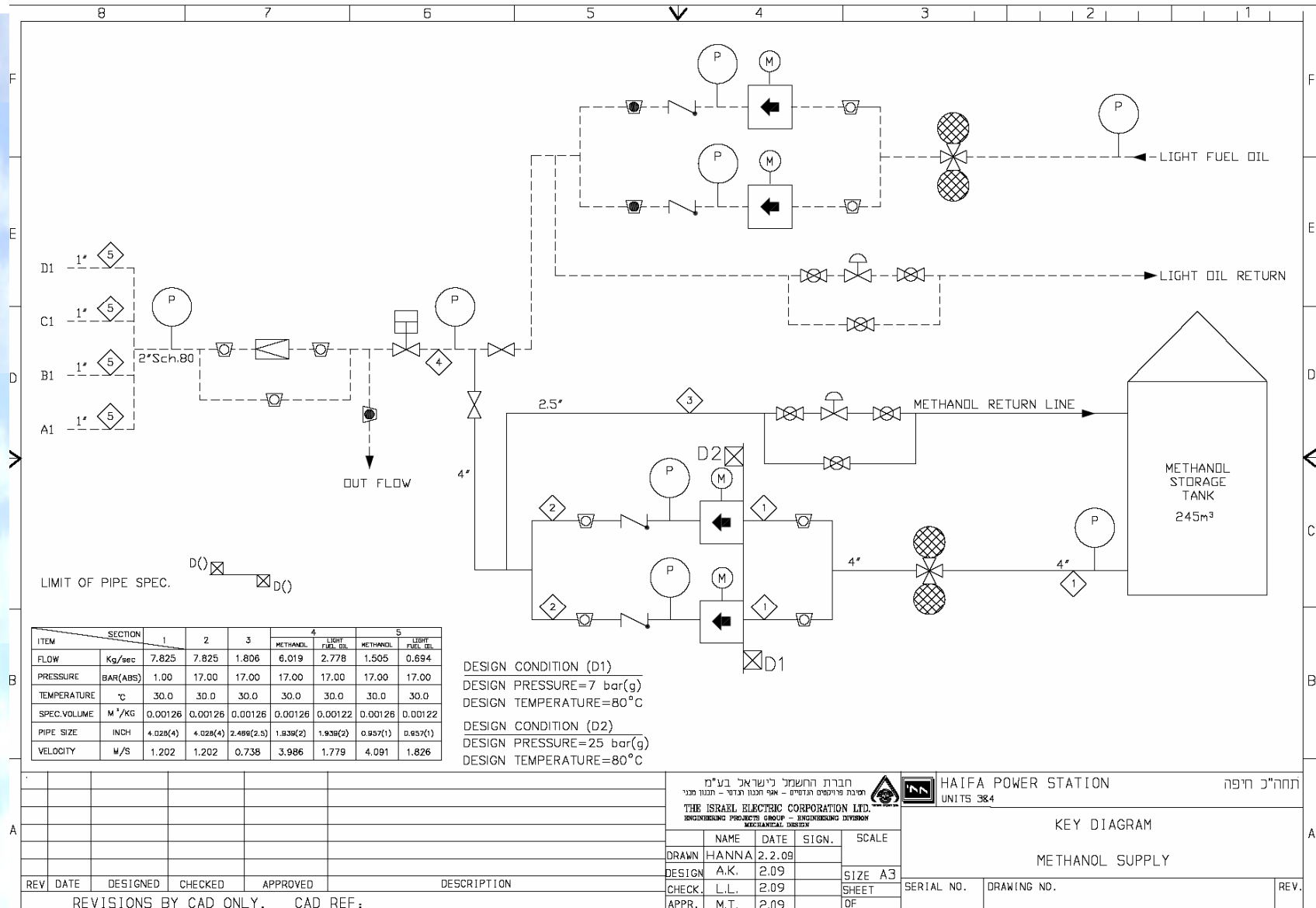


Upgrading for Methanol Firing Methanol Atomizer – General view





Upgrading for Methanol Firing Key Diagram



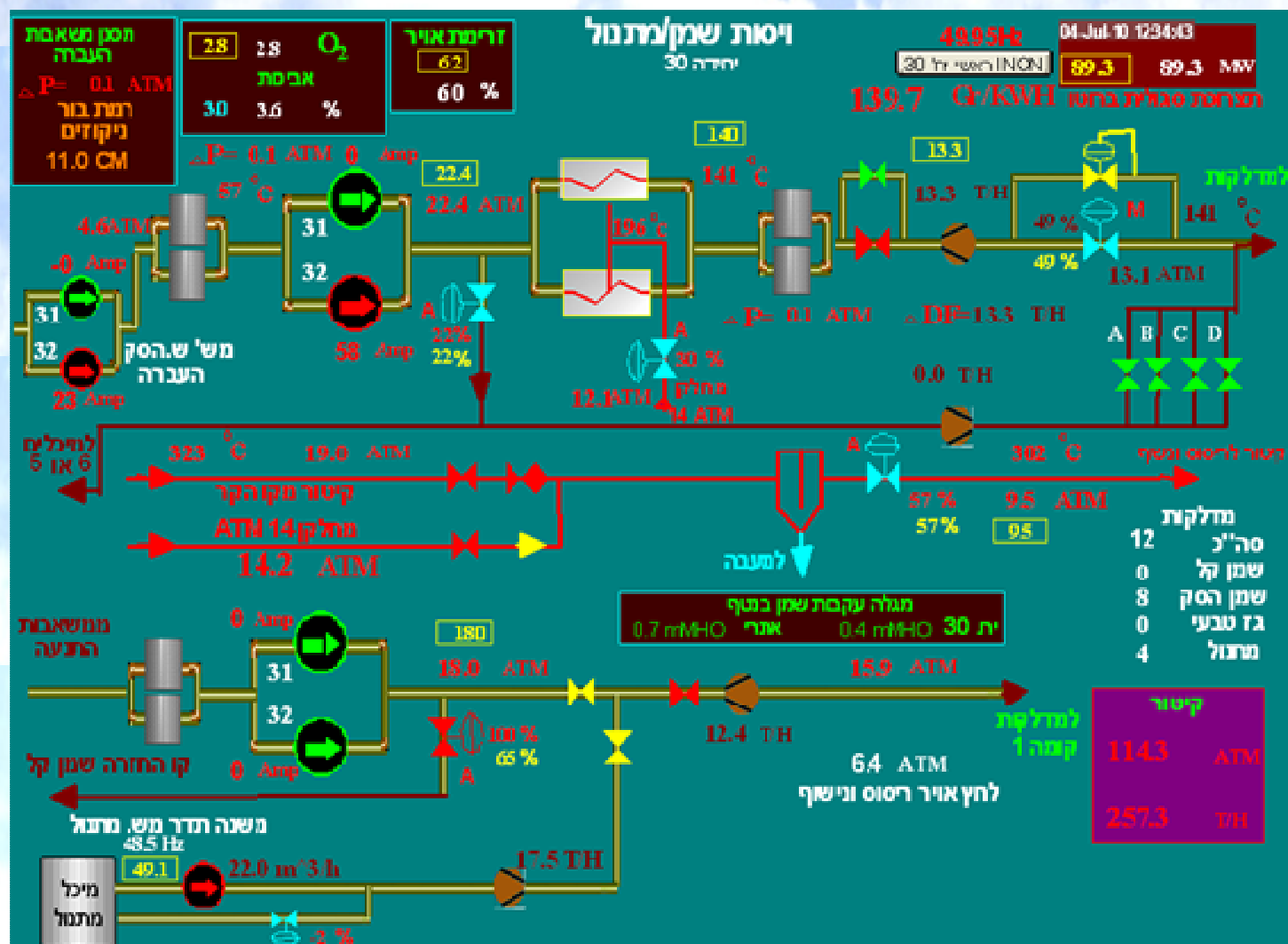


Methanol Storage Tank

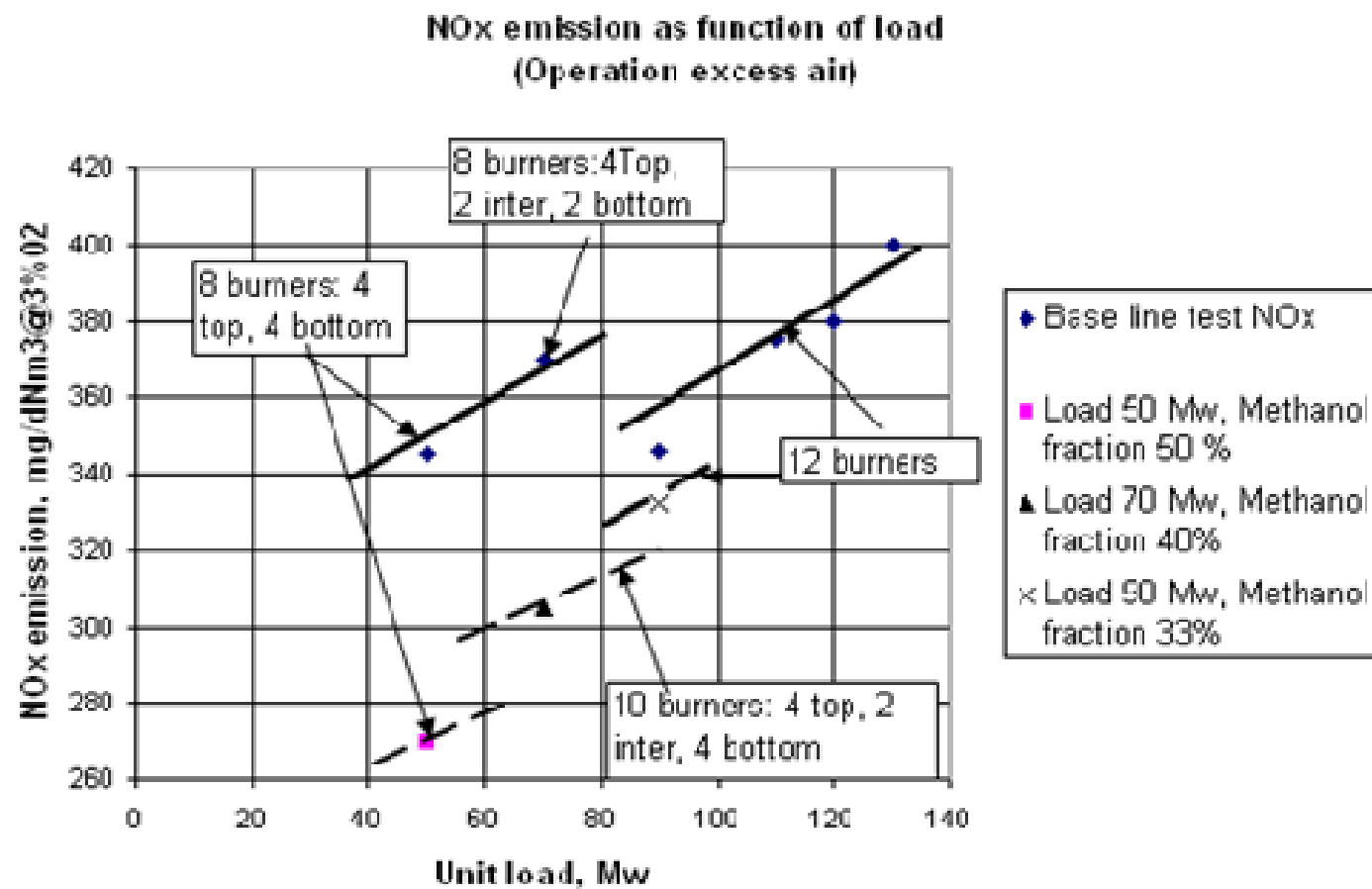
The Israel Electric Corp.



Methanol supply display



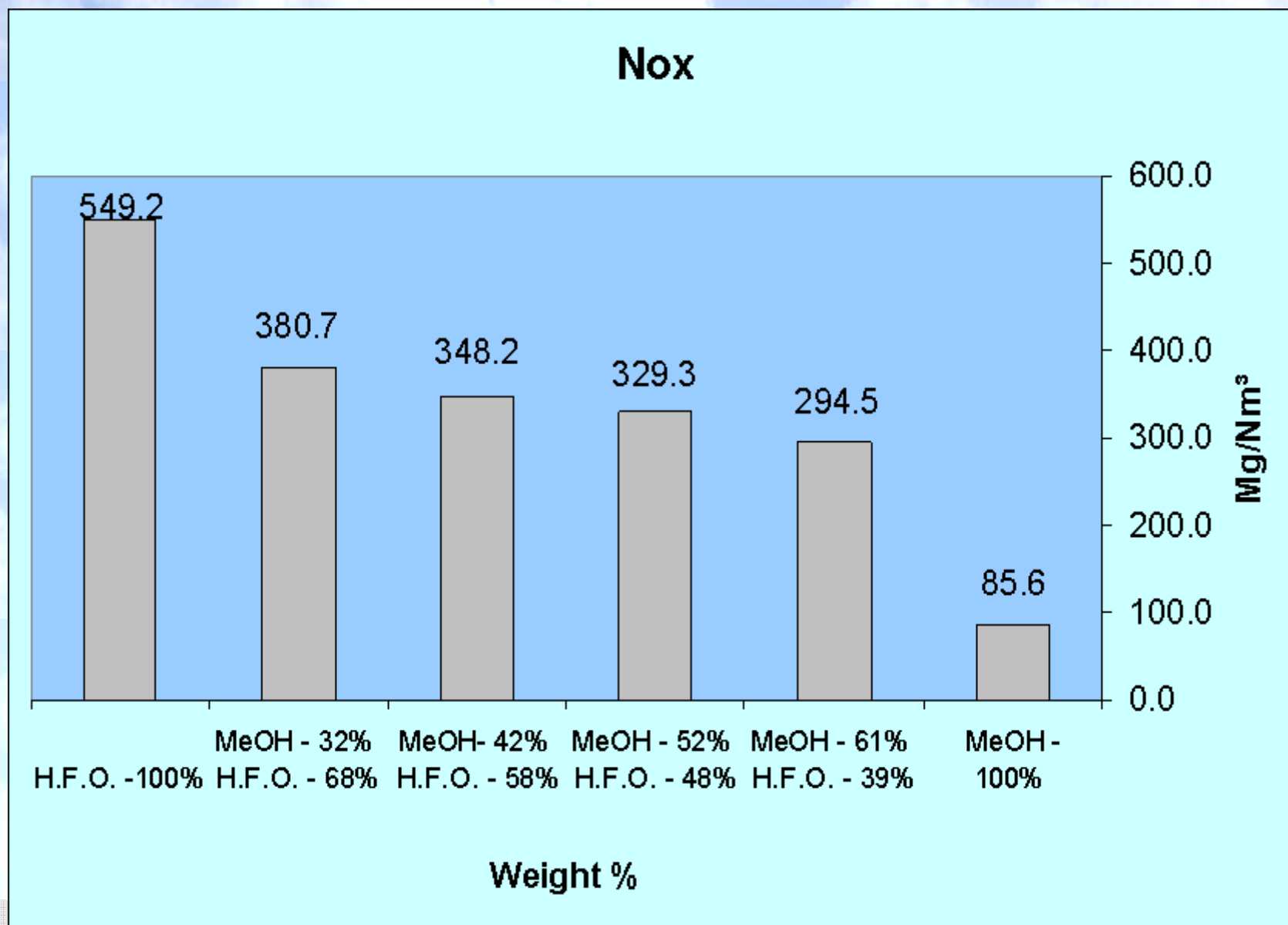
NOx reduction tests results Unit#3 Haifa PS Boiler



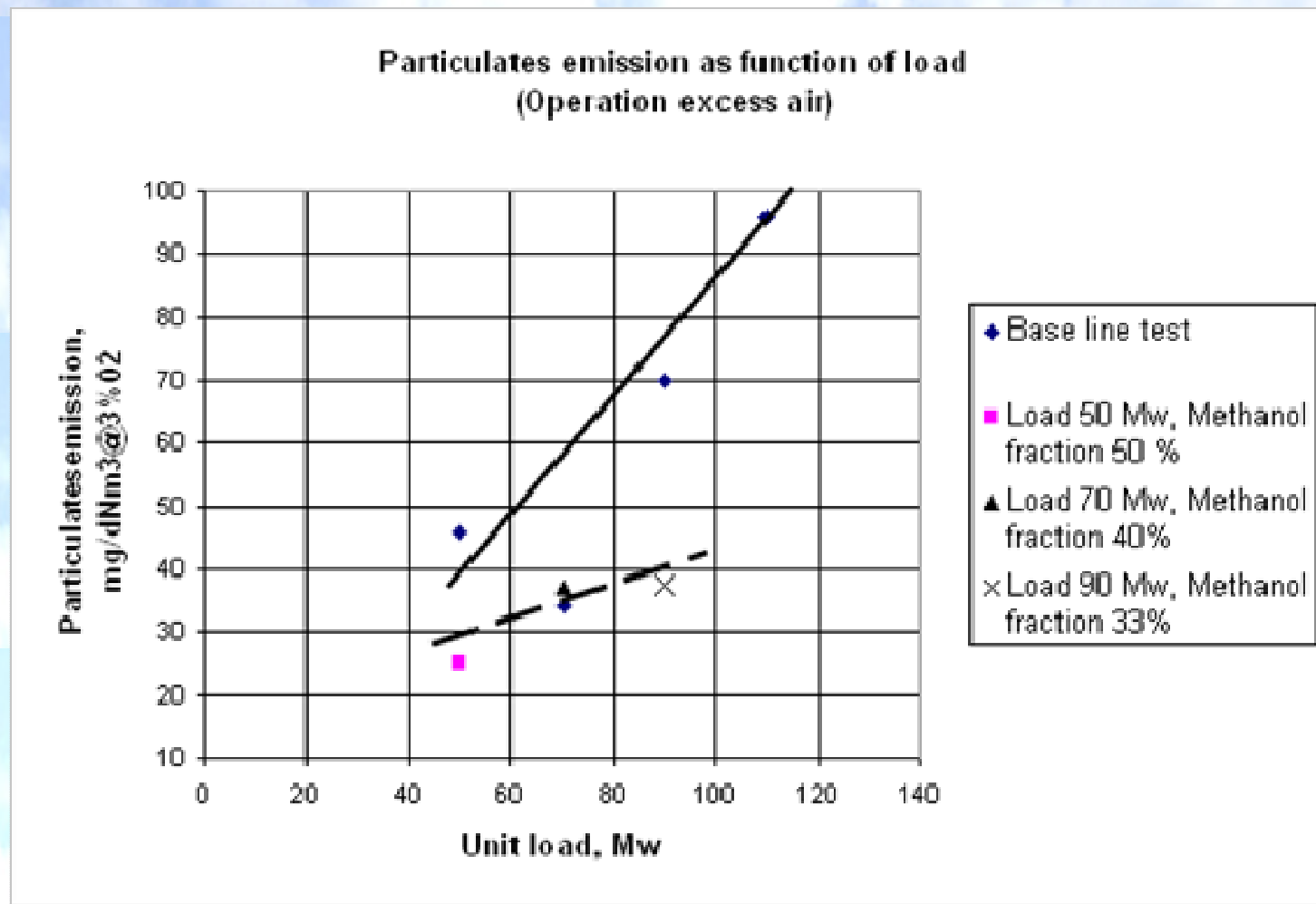


NO_x reduction tests results DOR Chemicals boiler (Capacity 10 t/h)

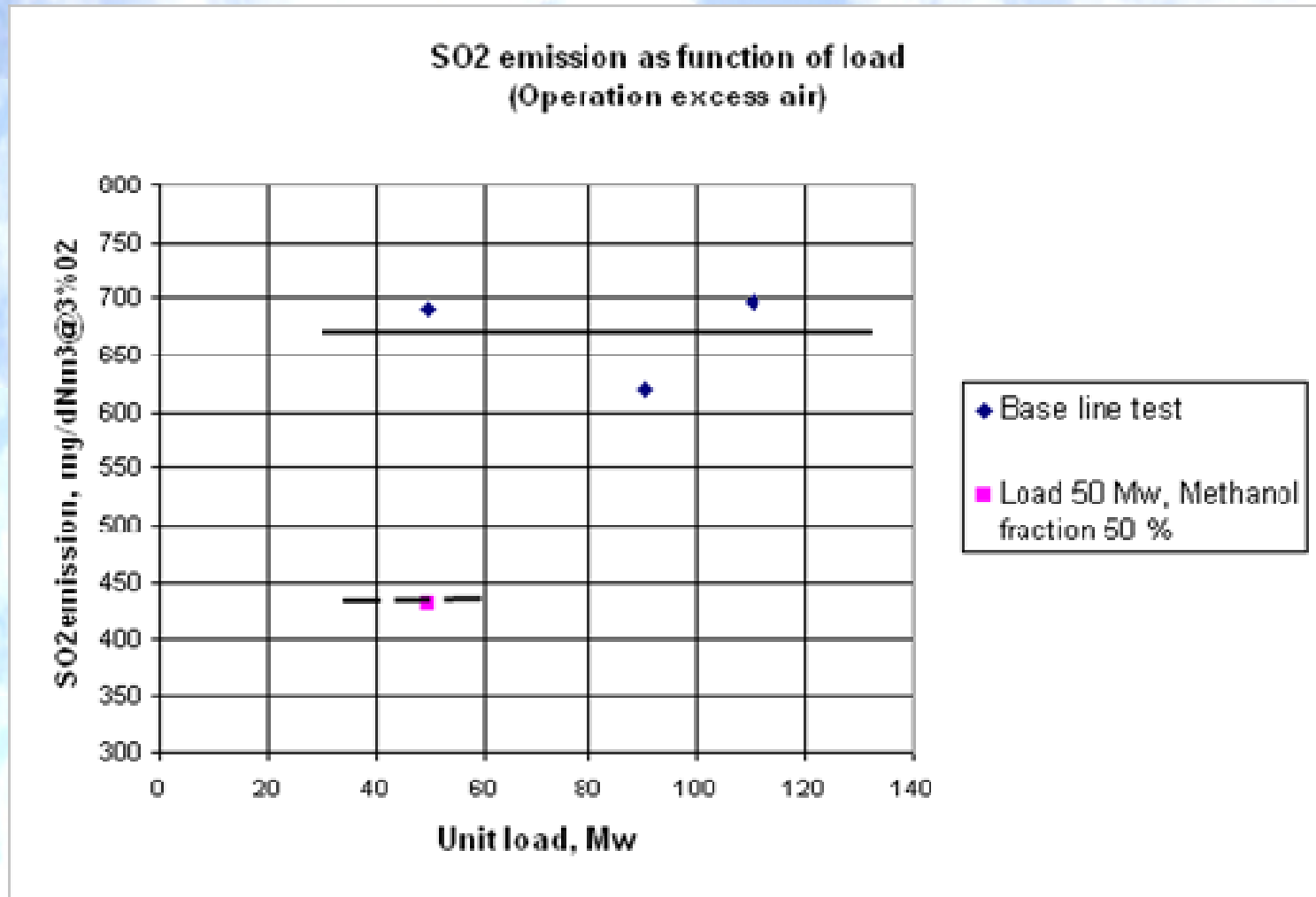
The Israel Electric Corp.



Particulates reduction tests results Unit#3 Haifa PS Boiler



SO₂ reduction tests results Unit#3 Haifa PS Boiler





Other emission reduction tests results

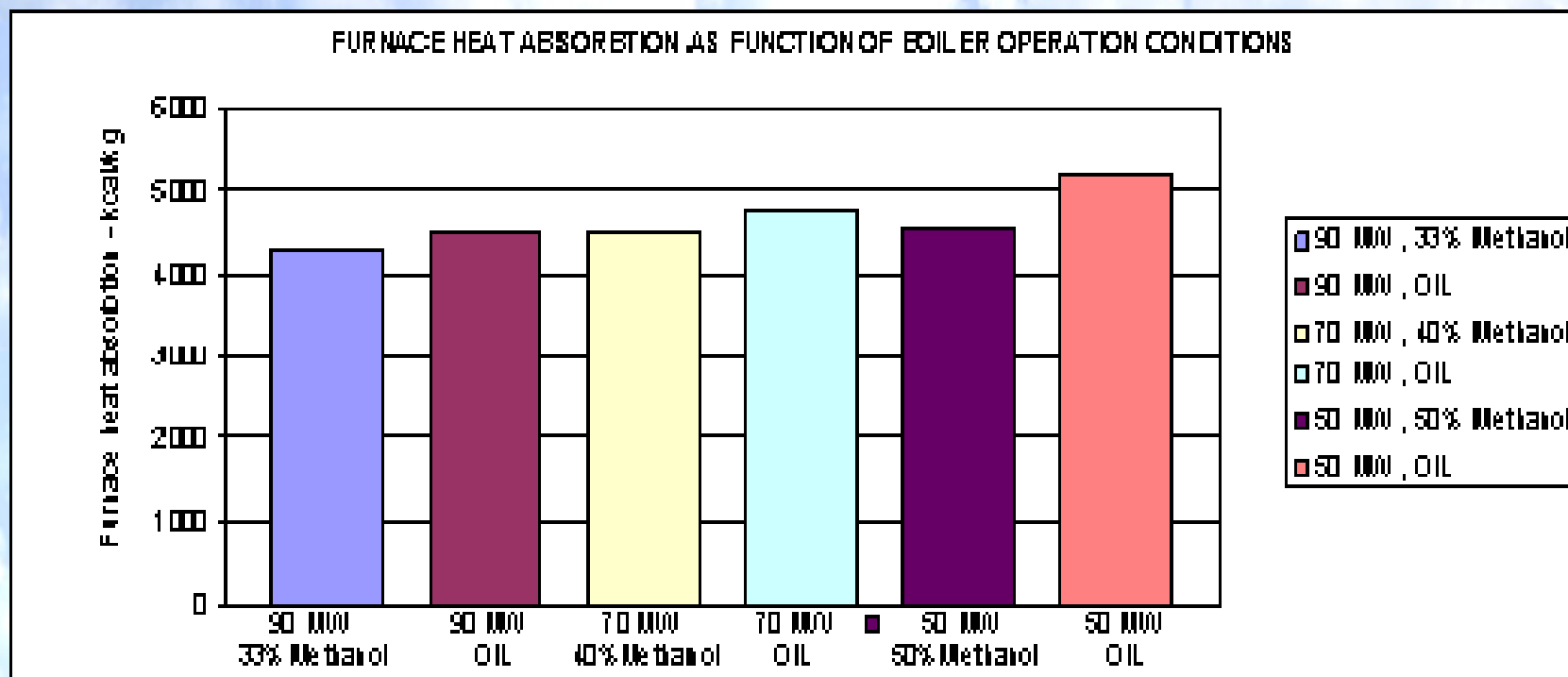
Unit#3 Haifa PS Boiler

CO emission - “o”

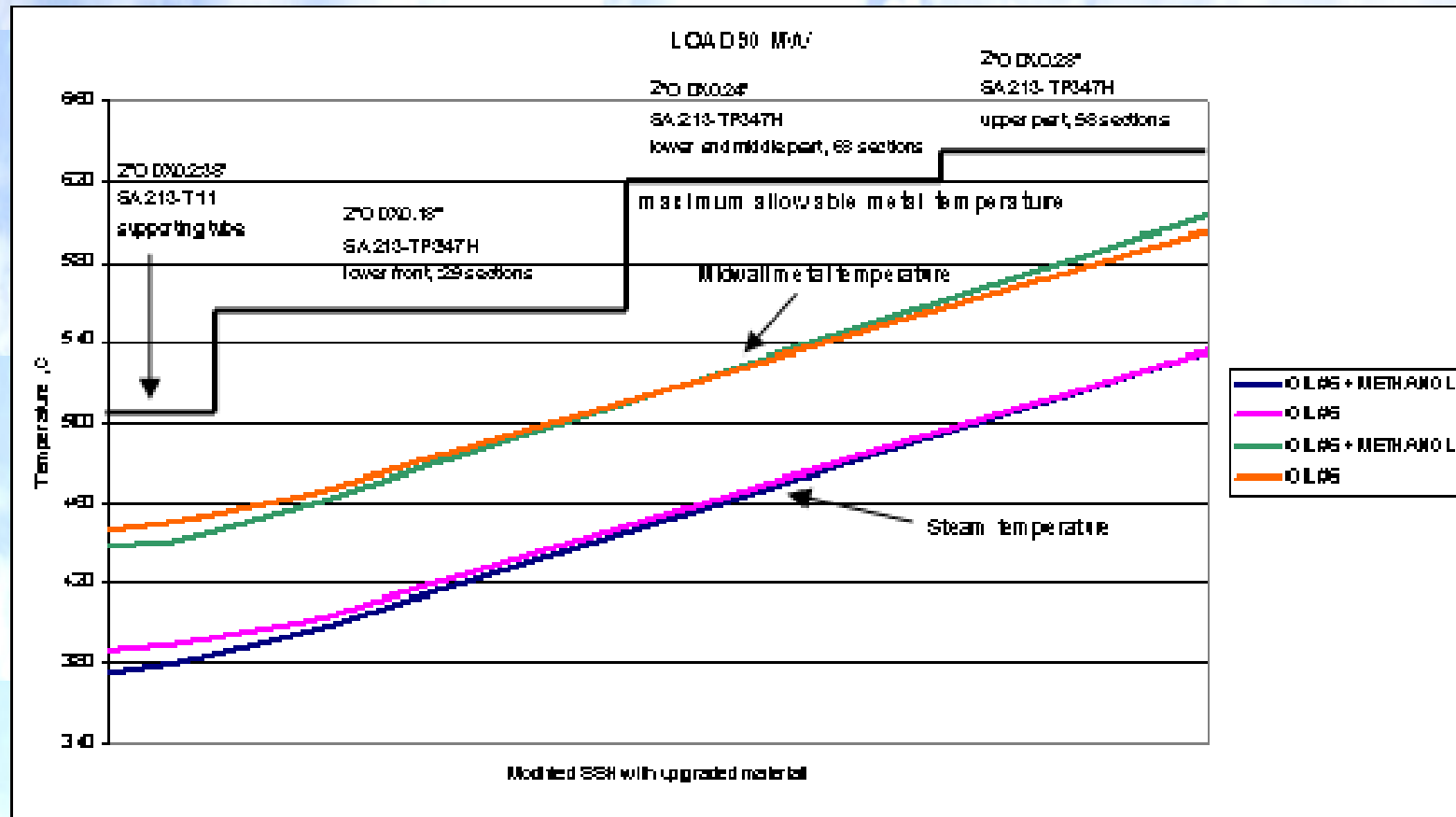
Formaldehyde - “o”



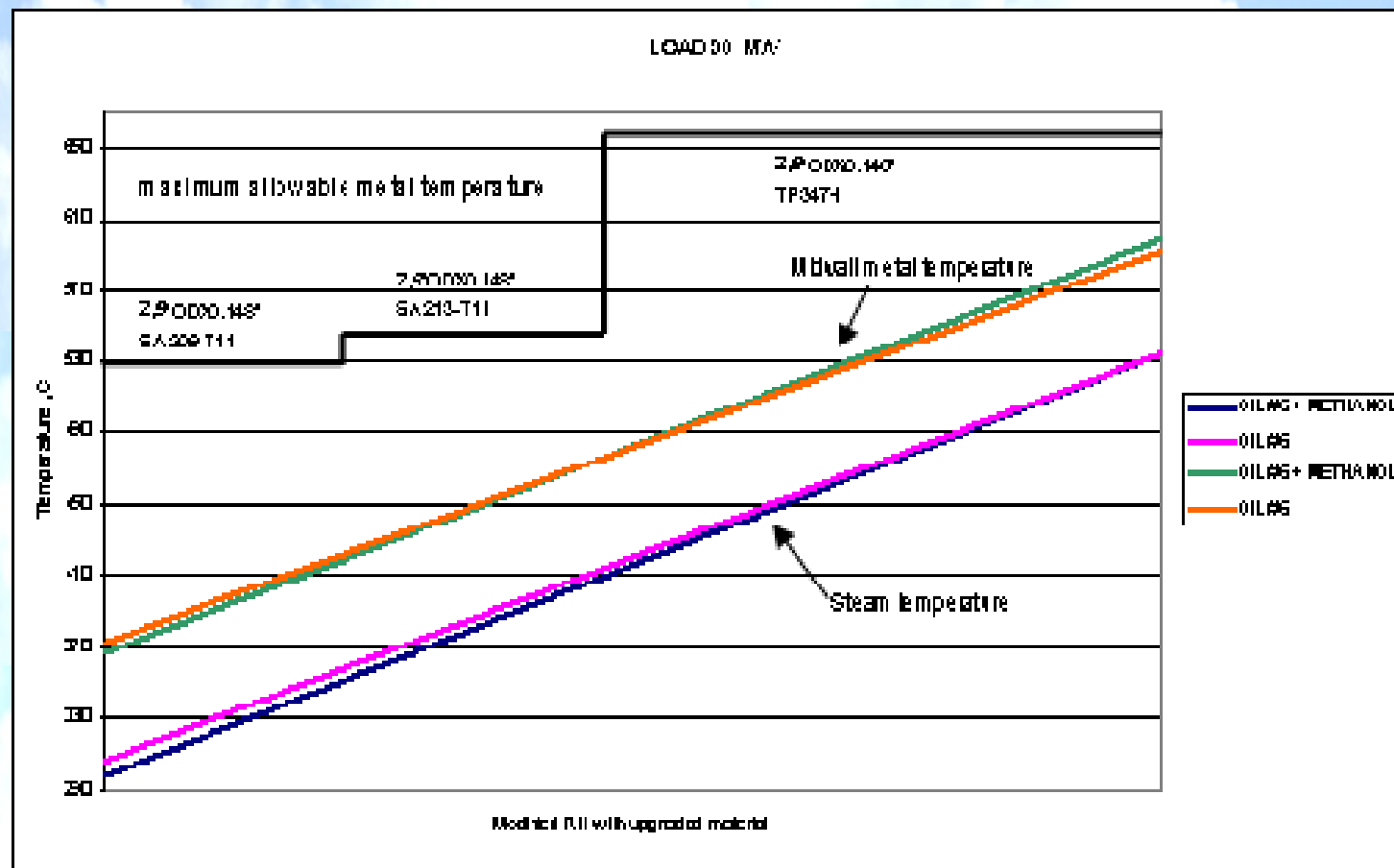
Comparison of furnace heat absorption for HFO and HFO-metanol co-firing



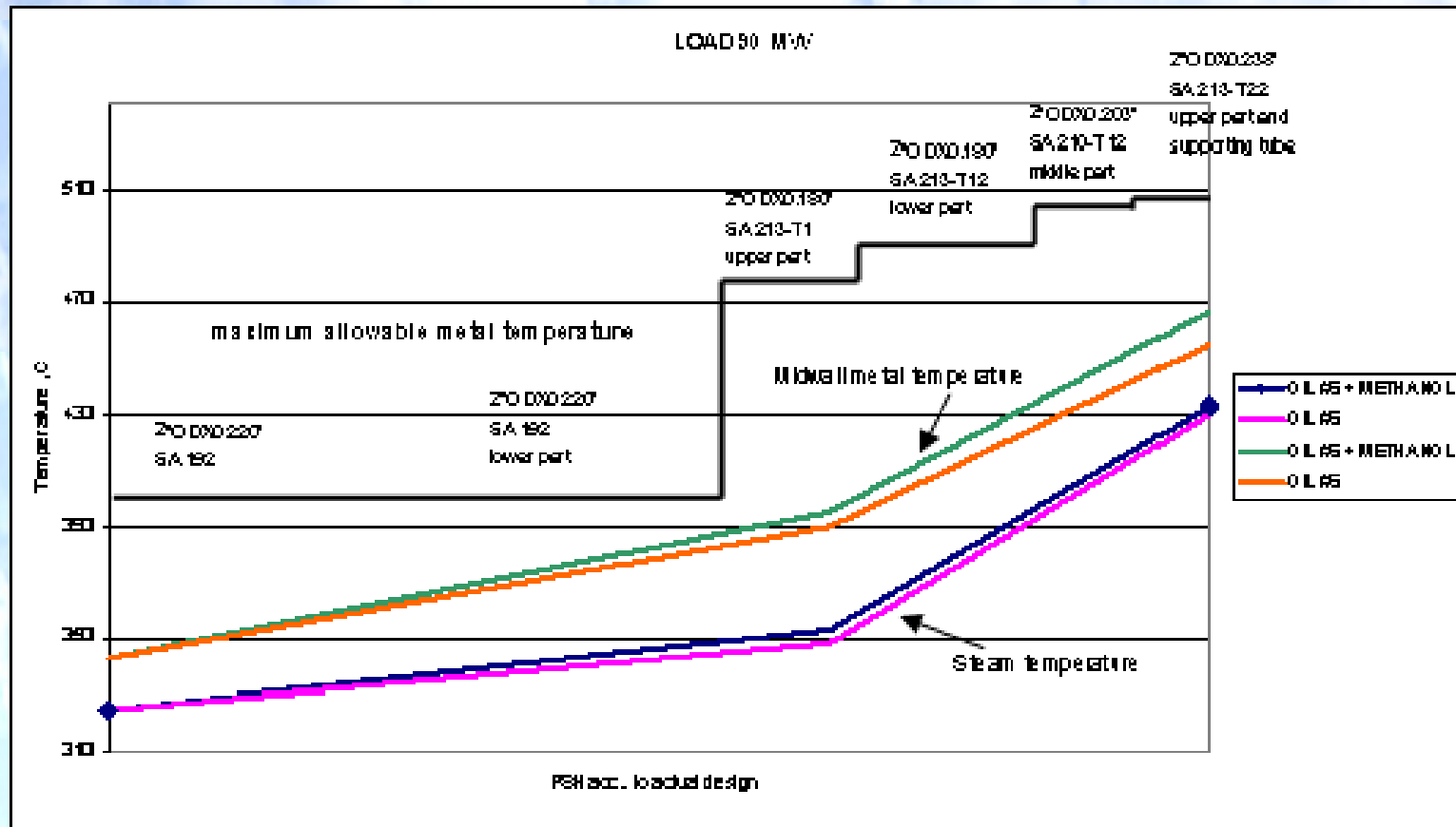
Secondary Superheater metal temperature (90MW)



Reheater metal temperature (90MW)



Primary superheater metal temperature (90MW)





HFO-Methanol Co-Firing Test Results

Unit Load, Mw	NO _x , mg/dNm ³ @15%		CO, mg/dNm ³ @15%		Particulates mg/dNm ³ @15%		SO ₂ , mg/dNm ³ @15%	
	HFO	HFO-Met Co-Firing	HFO	HFO-Met Co-Firing	HFO	HFO-Met Co-Firing	HFO	HFO-Met Co-Firing
50	345	270	Negligible	Negligible	47	25	690	350
70	370	300	Negligible	Negligible	60	37	690	410
90	380	330	Negligible	Negligible	70	38	690	460





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Methanol Firing at FT4C TWIN PAC 50 MWe GT Unit



Caesarea Power Plant Site



Tested unit



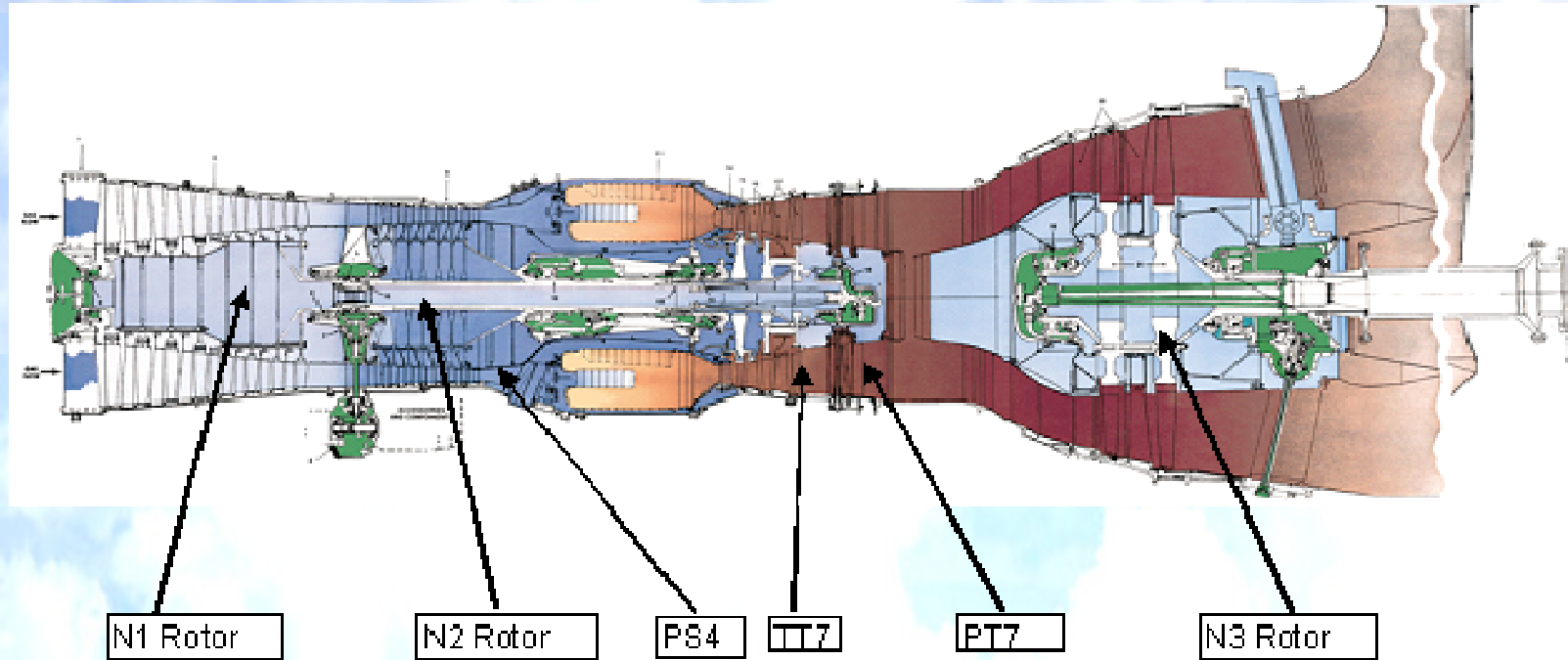
The Israel Electric Corp.



TP -1 Base Plate Assembly



FT4 – Engine & Power Turbine





Liner– General view





Liner– General view





Liner– General view



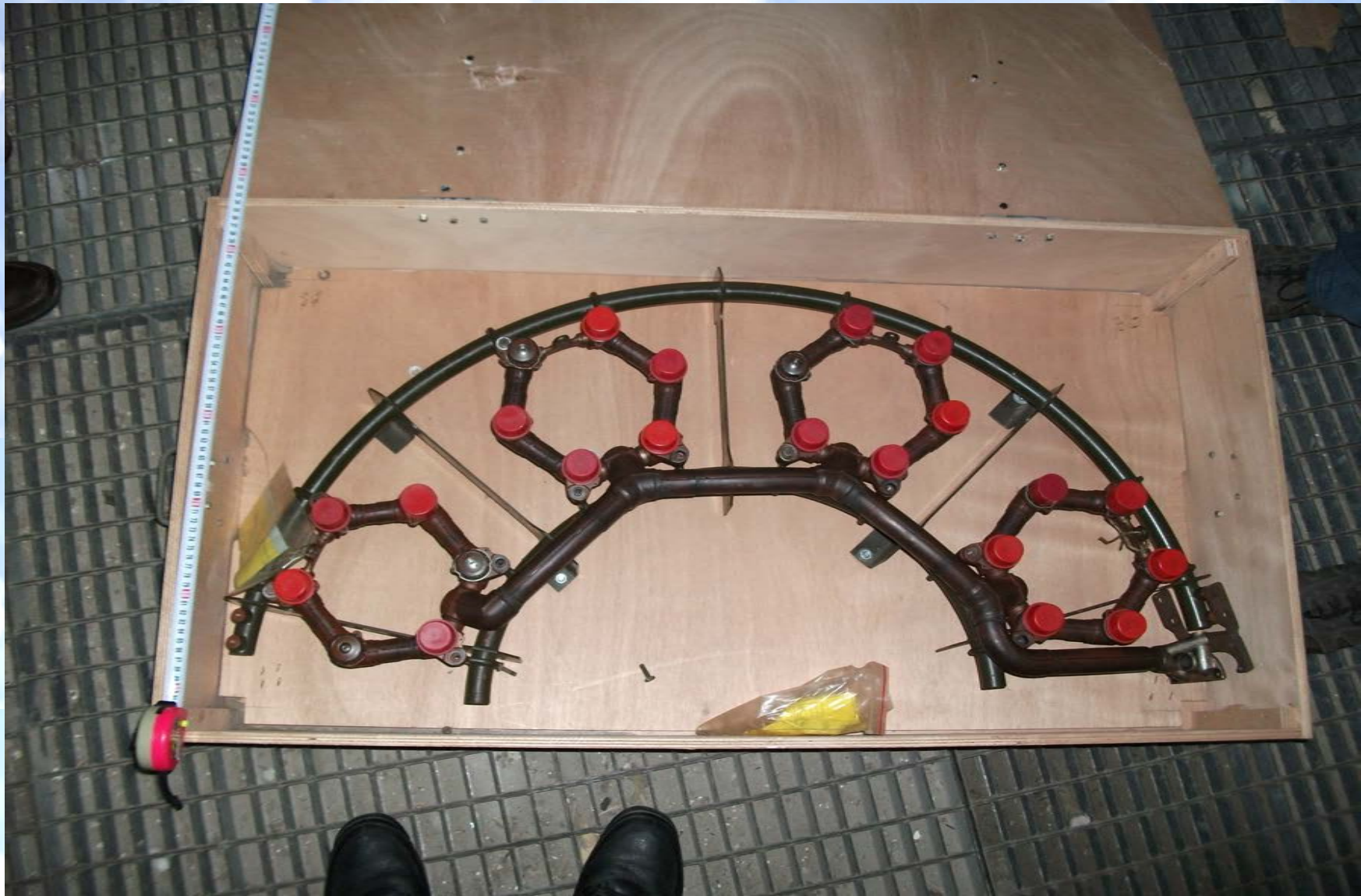


Nozzle– General view

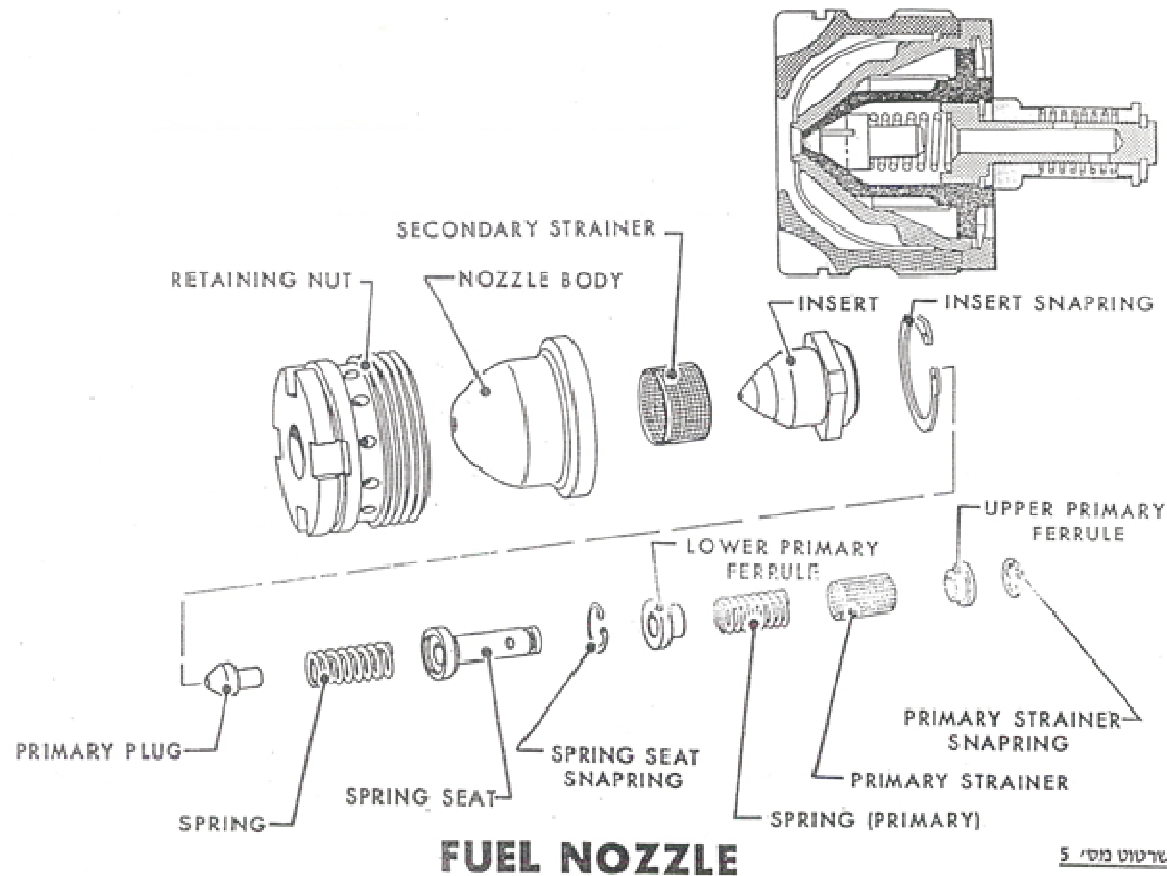




FO Atomizer Assembly– General view

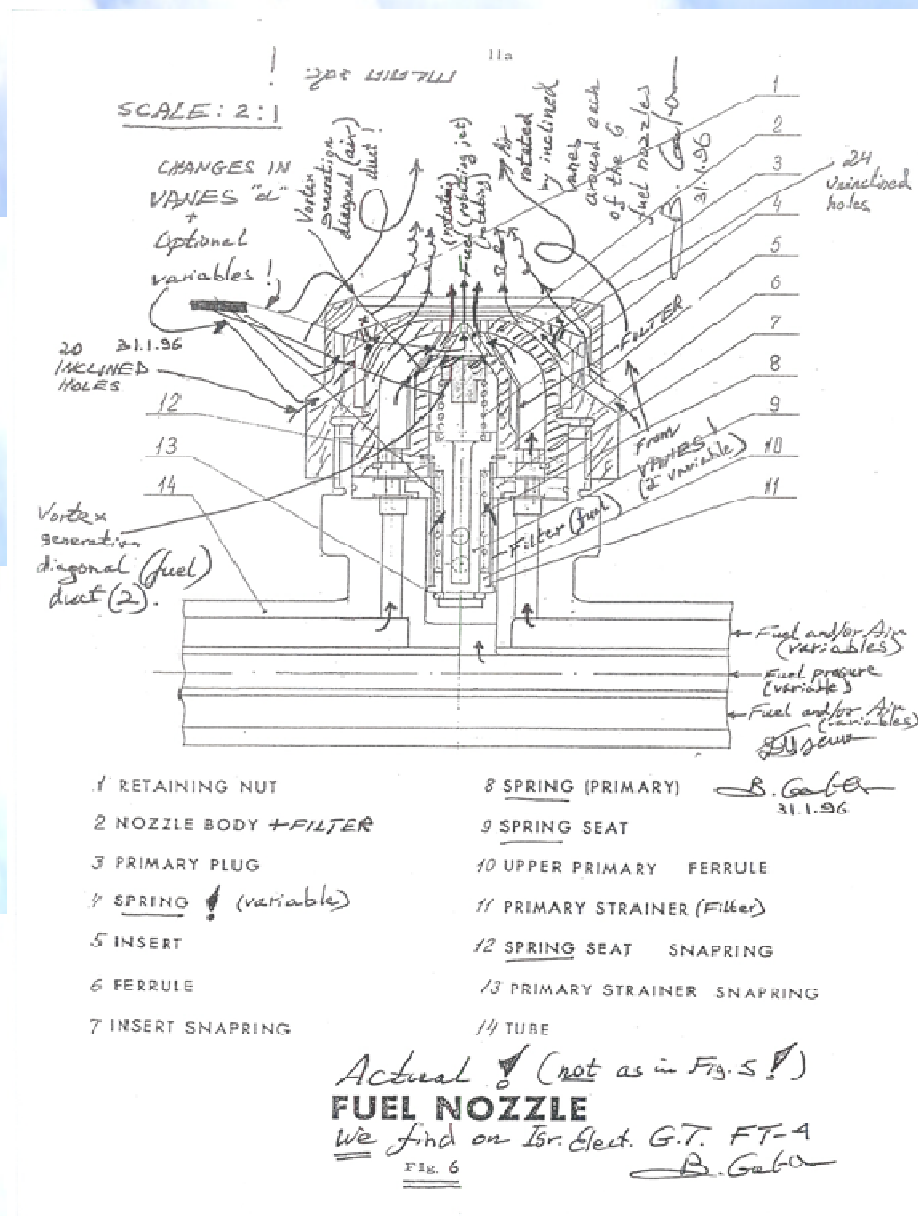


FO Atomizer – General view

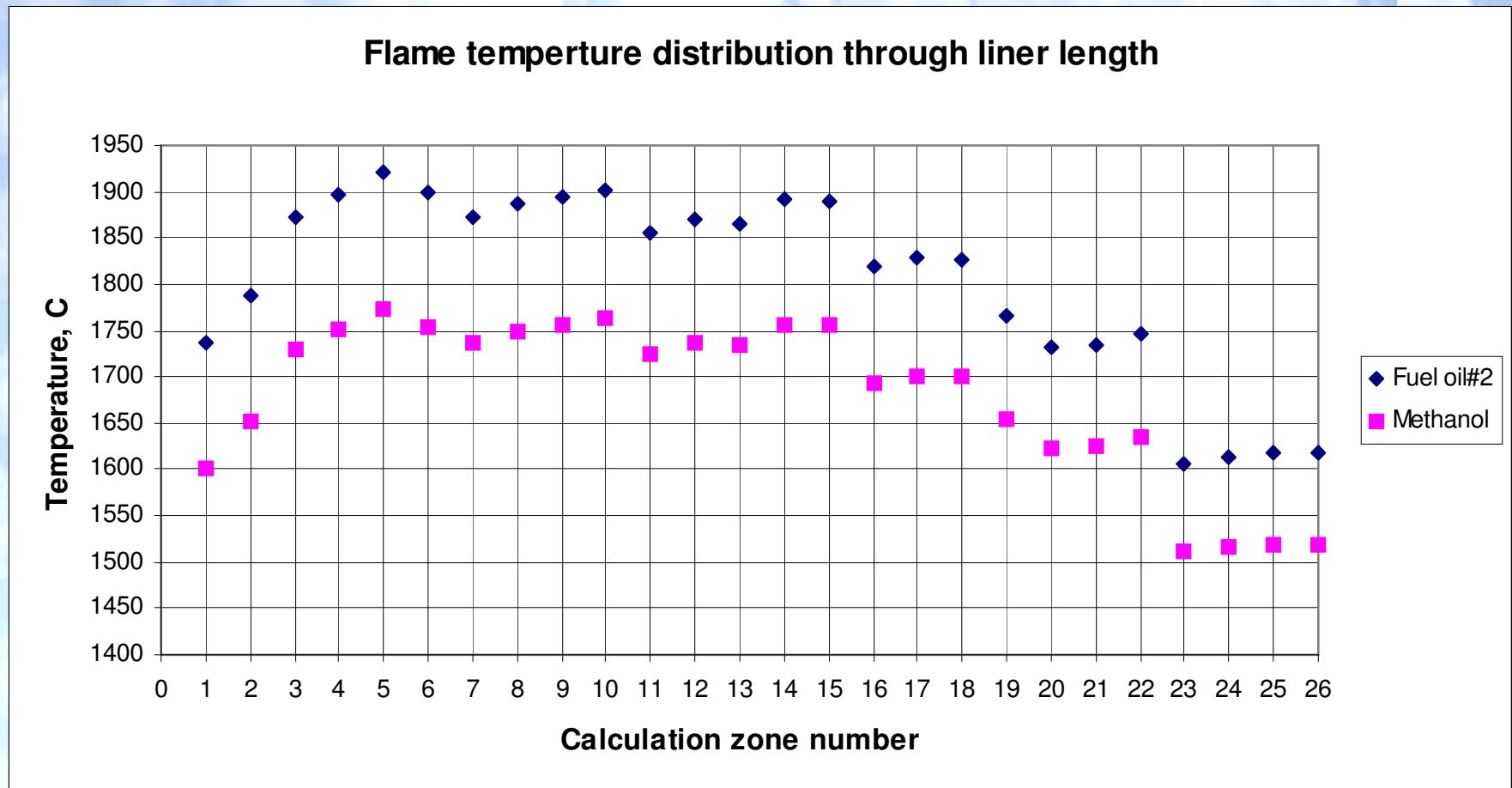


מבנה אחד מששת מוזיקי הדלק המשמשים בכל תא שריפה של תחמי. אמטוריות השינויים במוזיקי הדלק מרובות. אחדות מהן הוזכרו בסימוכין ולעיל וחלקם קשורים בצורך שיישקל לחסם את הסולר מעבר לסמפרטורה הקיימת כיום באתר תחמי בעת הפעולה הנורמת לעשו מירבי.

FO Supply Scheme

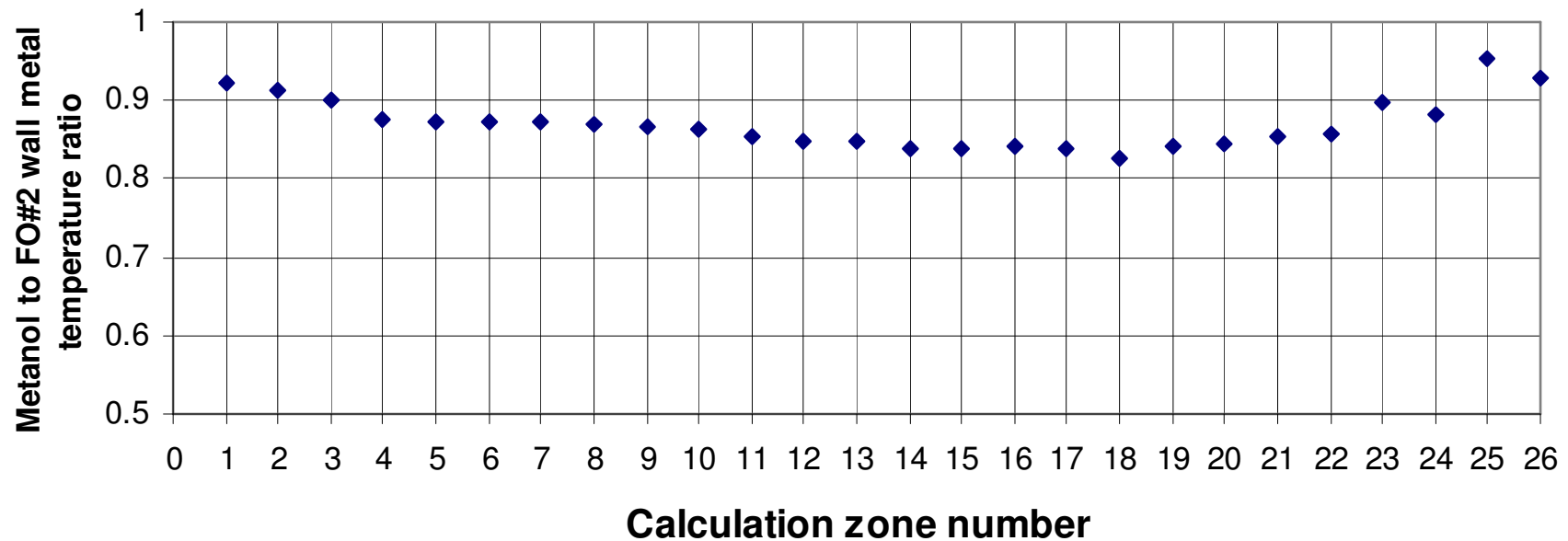


Calculated Flame Temperature Distribution 100% Load

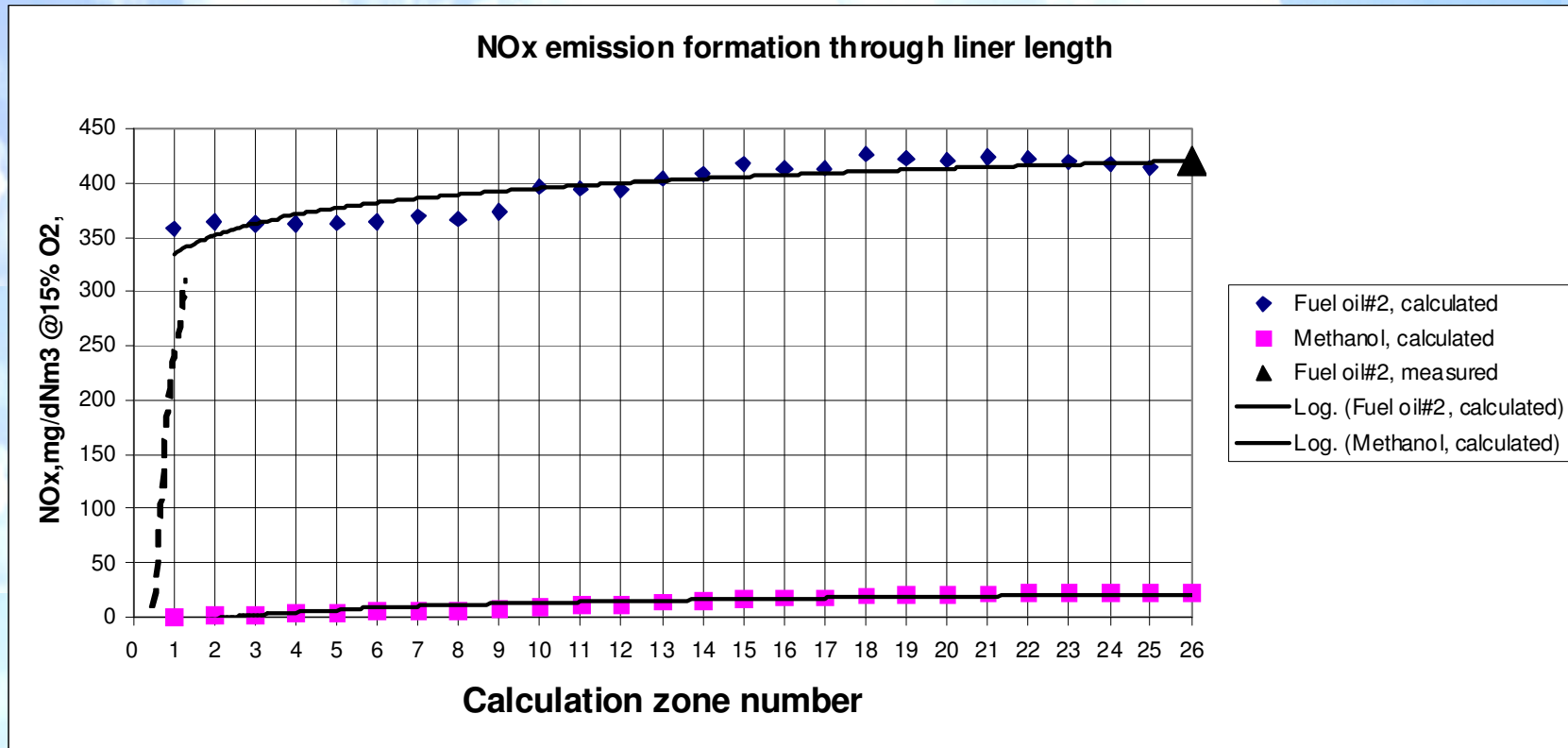


Calculated Liner Wall Temperature Distribution 100% Load

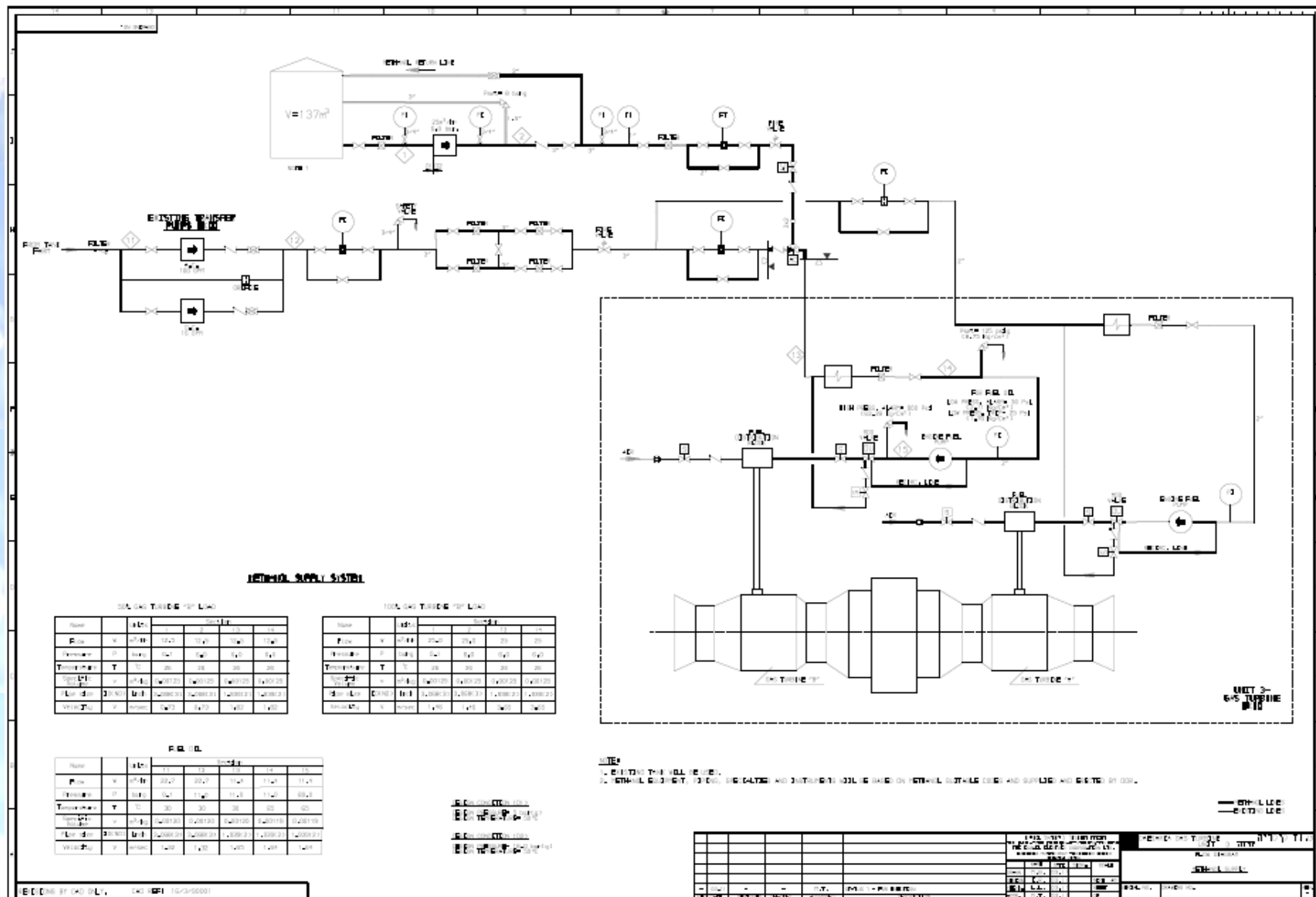
Relative liner wall metal temperature reduction during
methanol burning



Comparison of NO_x Formation Through Liner Length for FO#2 and Methanol Firing 100% Load



Upgrading for Methanol Firing





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Methanol Test Methanol tank





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Methanol Test piping connection





Methanol Test Control Room Display



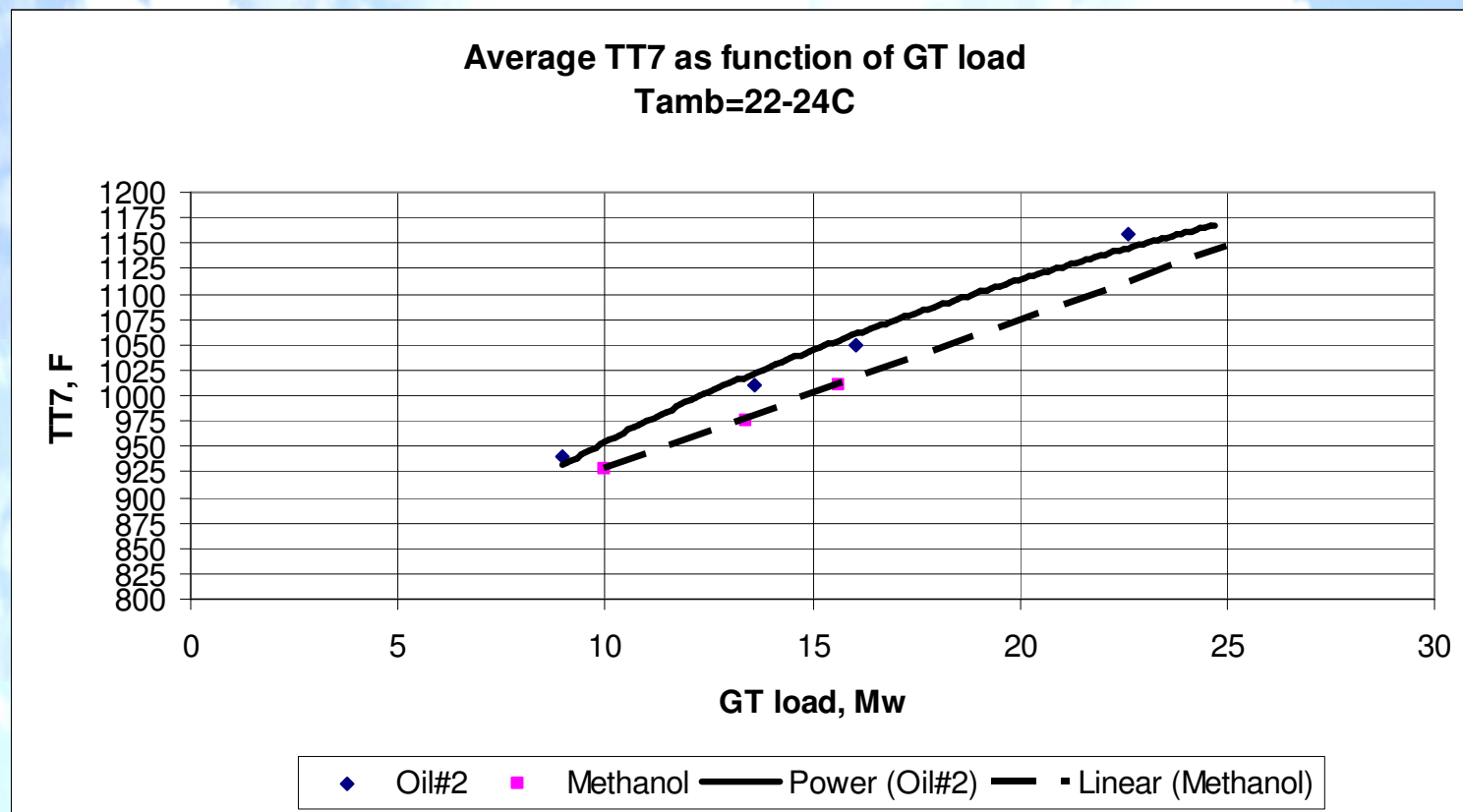


Methanol Test Emission measurements instruments general view

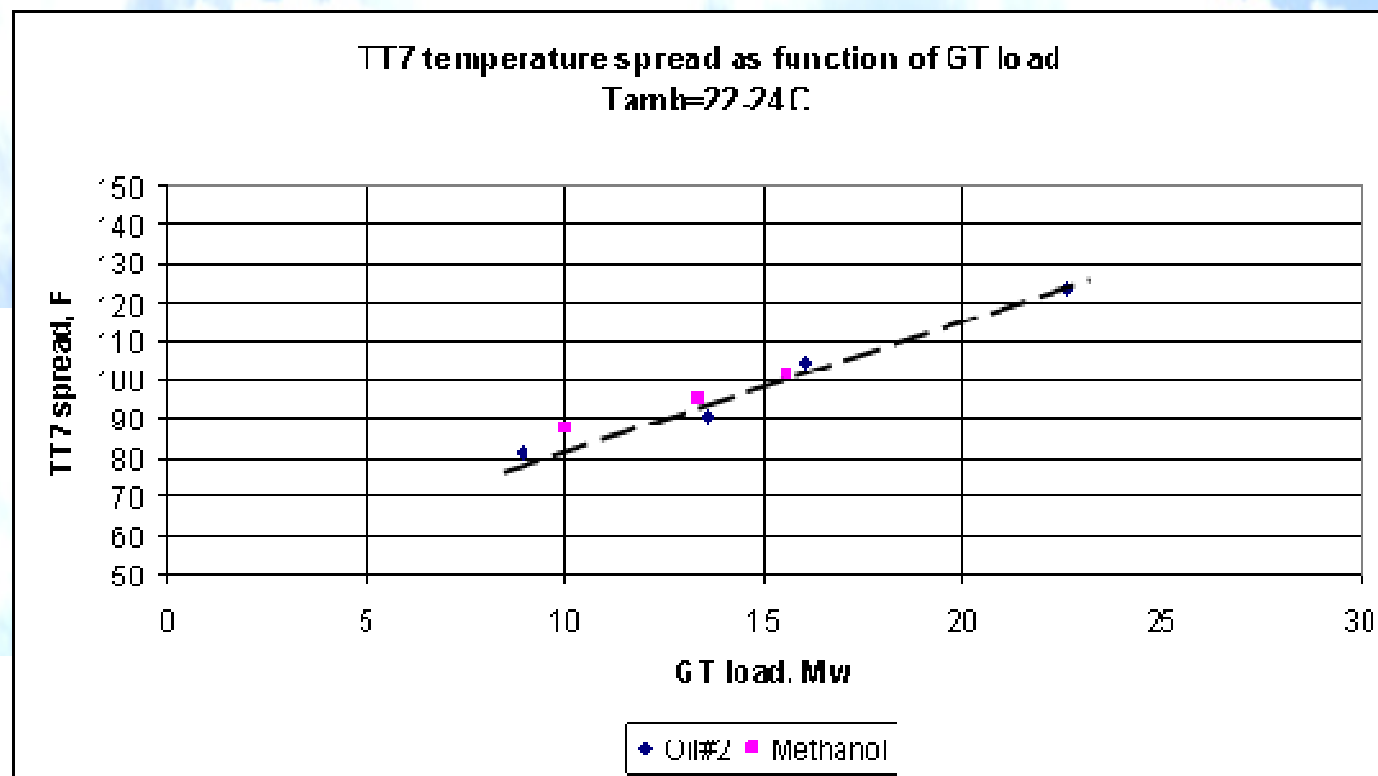




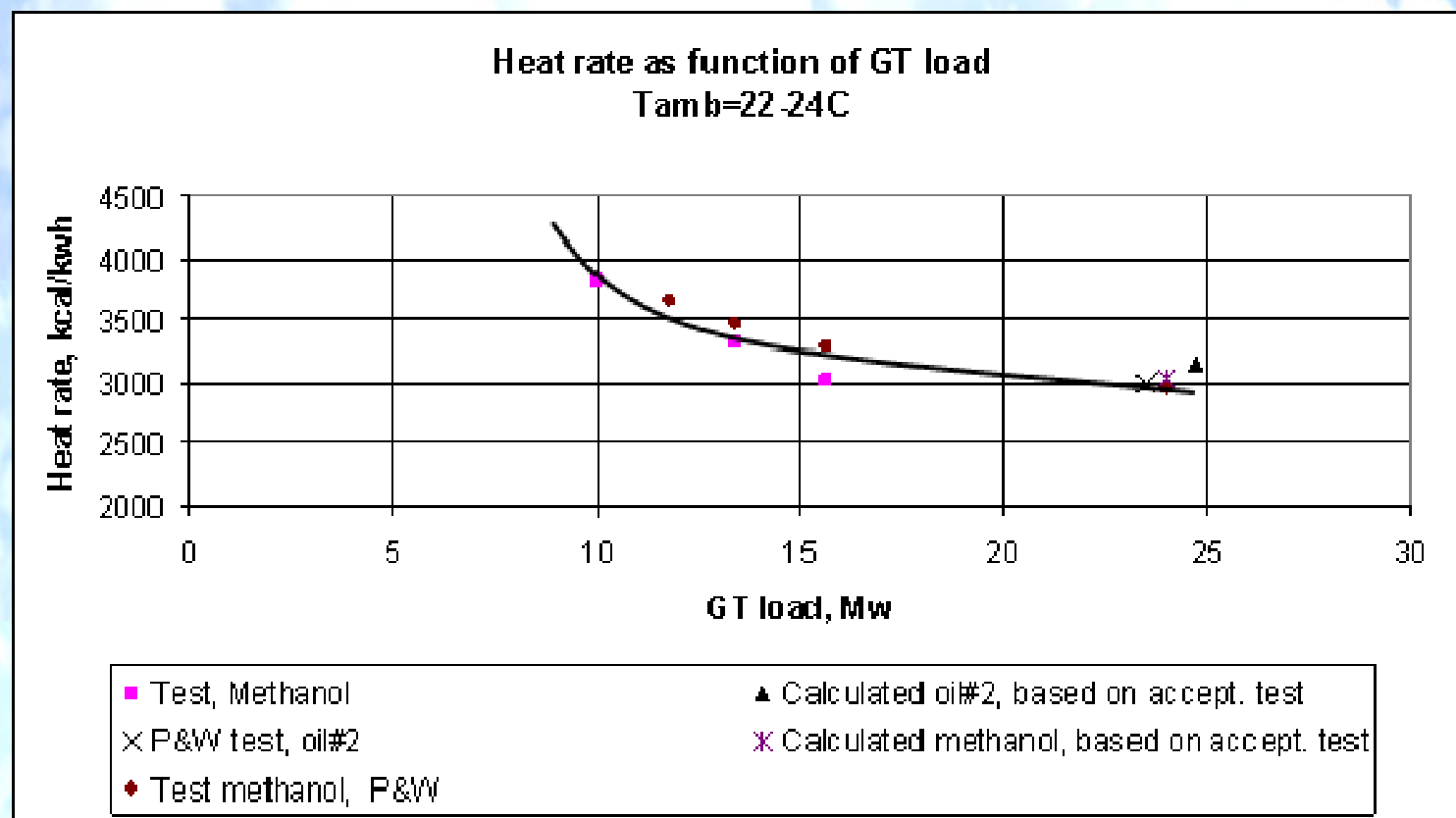
Methanol Test Results



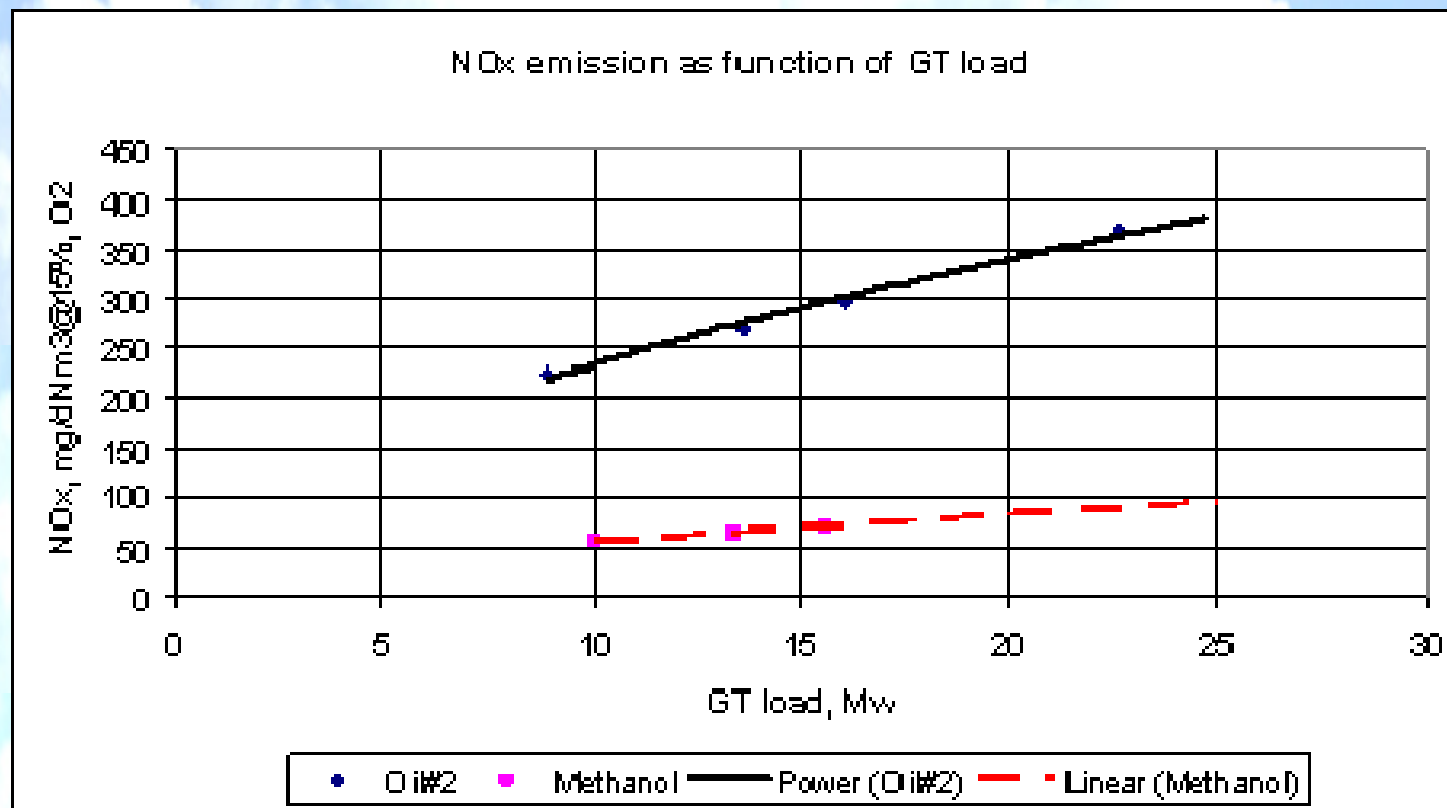
Methanol Test Results



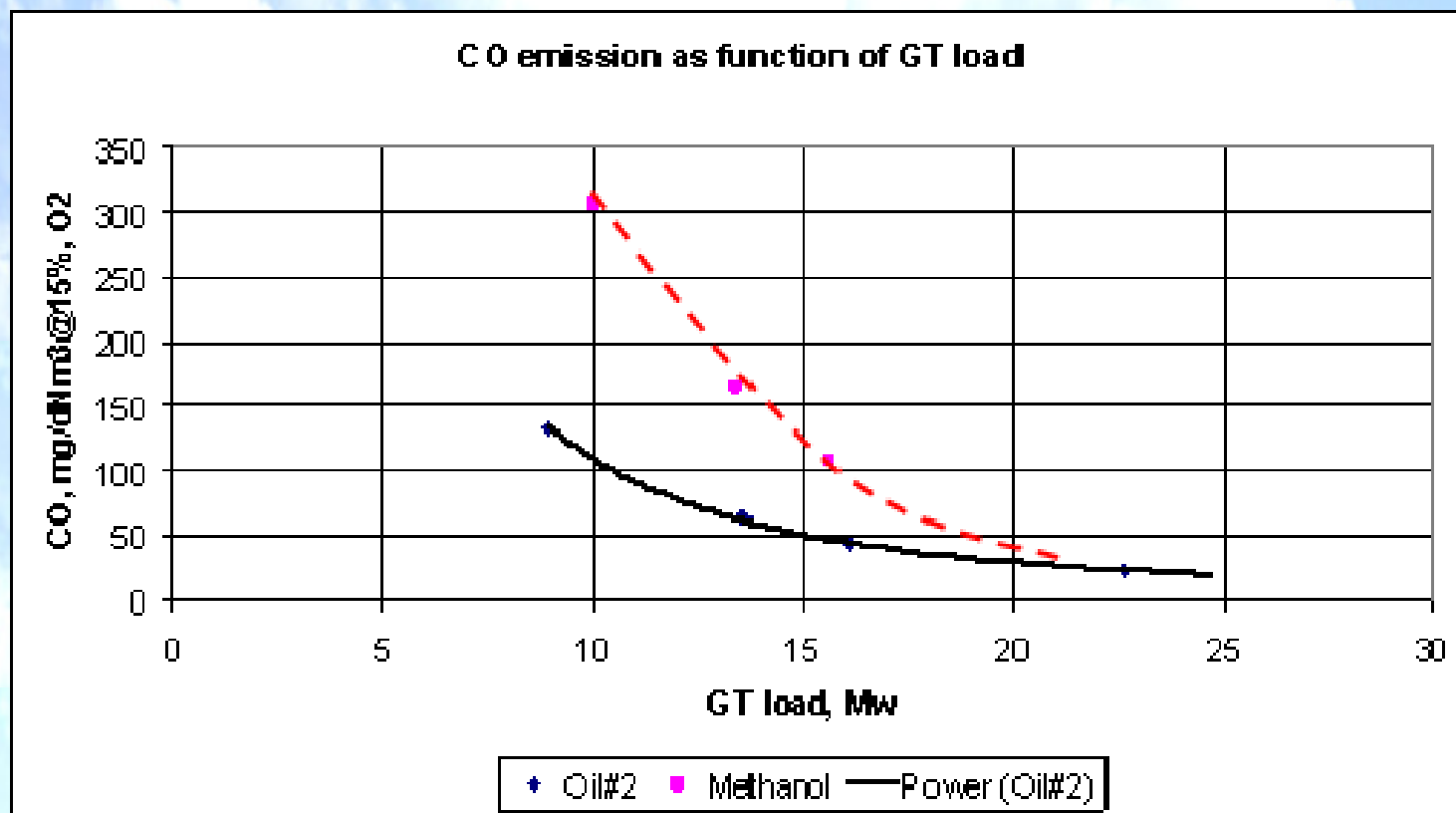
Methanol Test Results



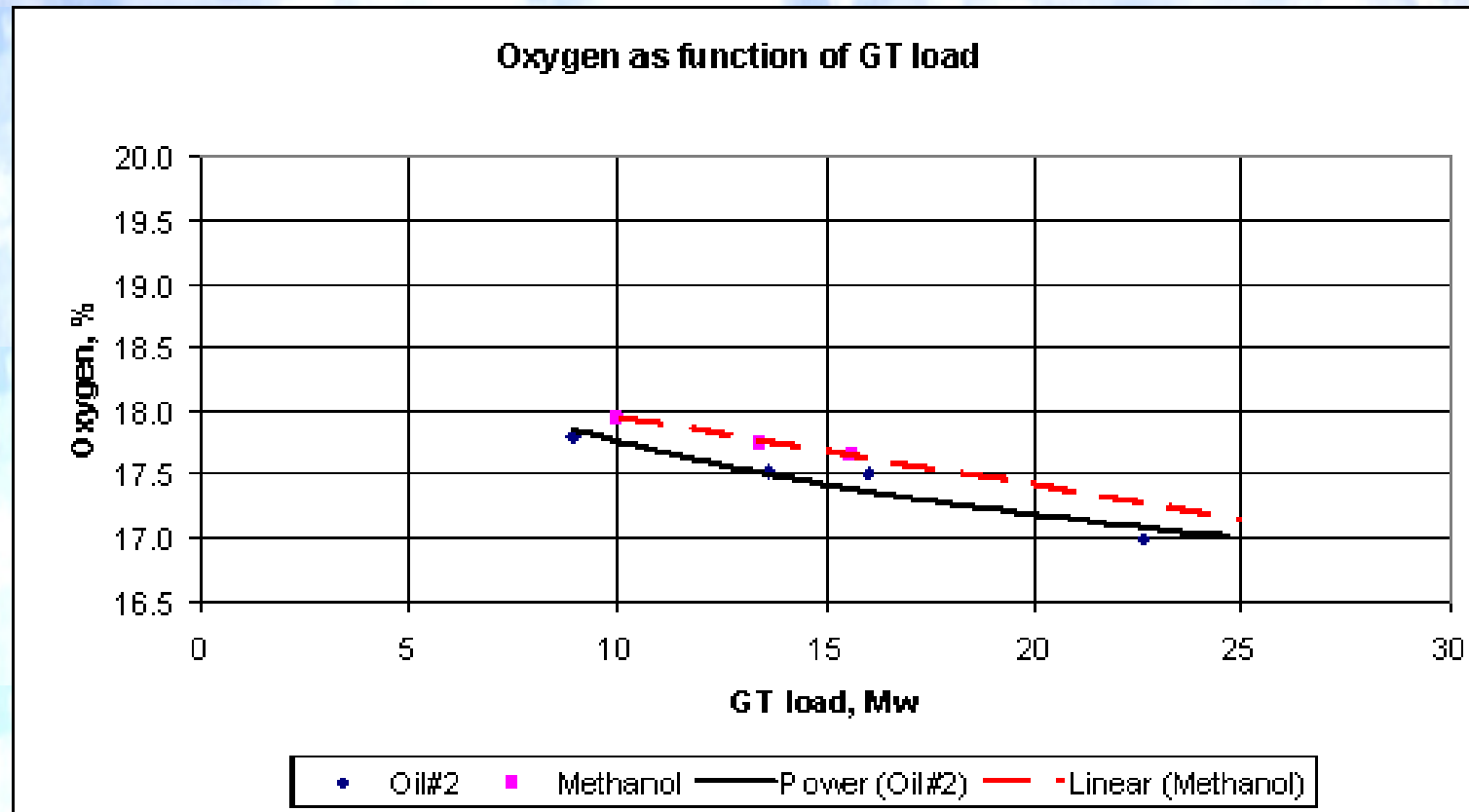
Methanol Test Results



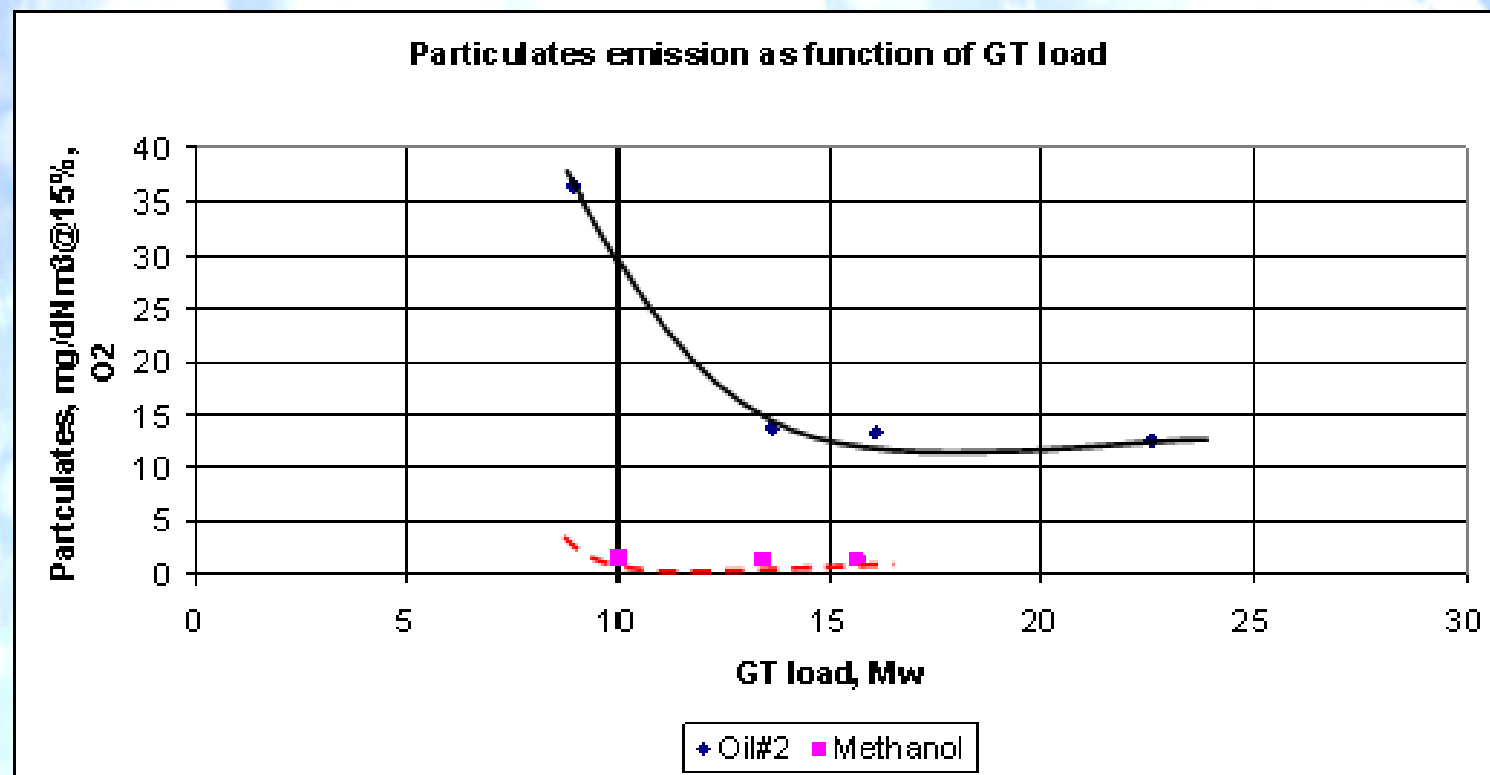
Methanol Test Results



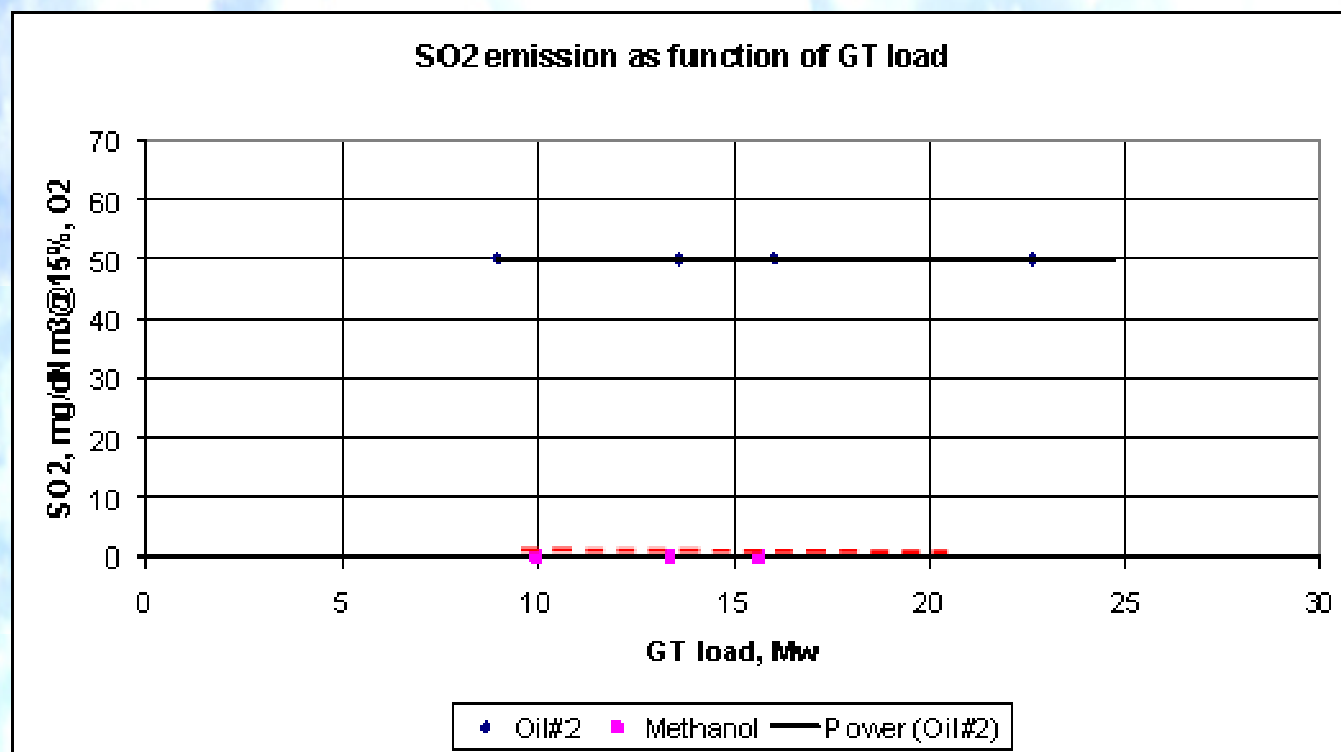
Methanol Test Results



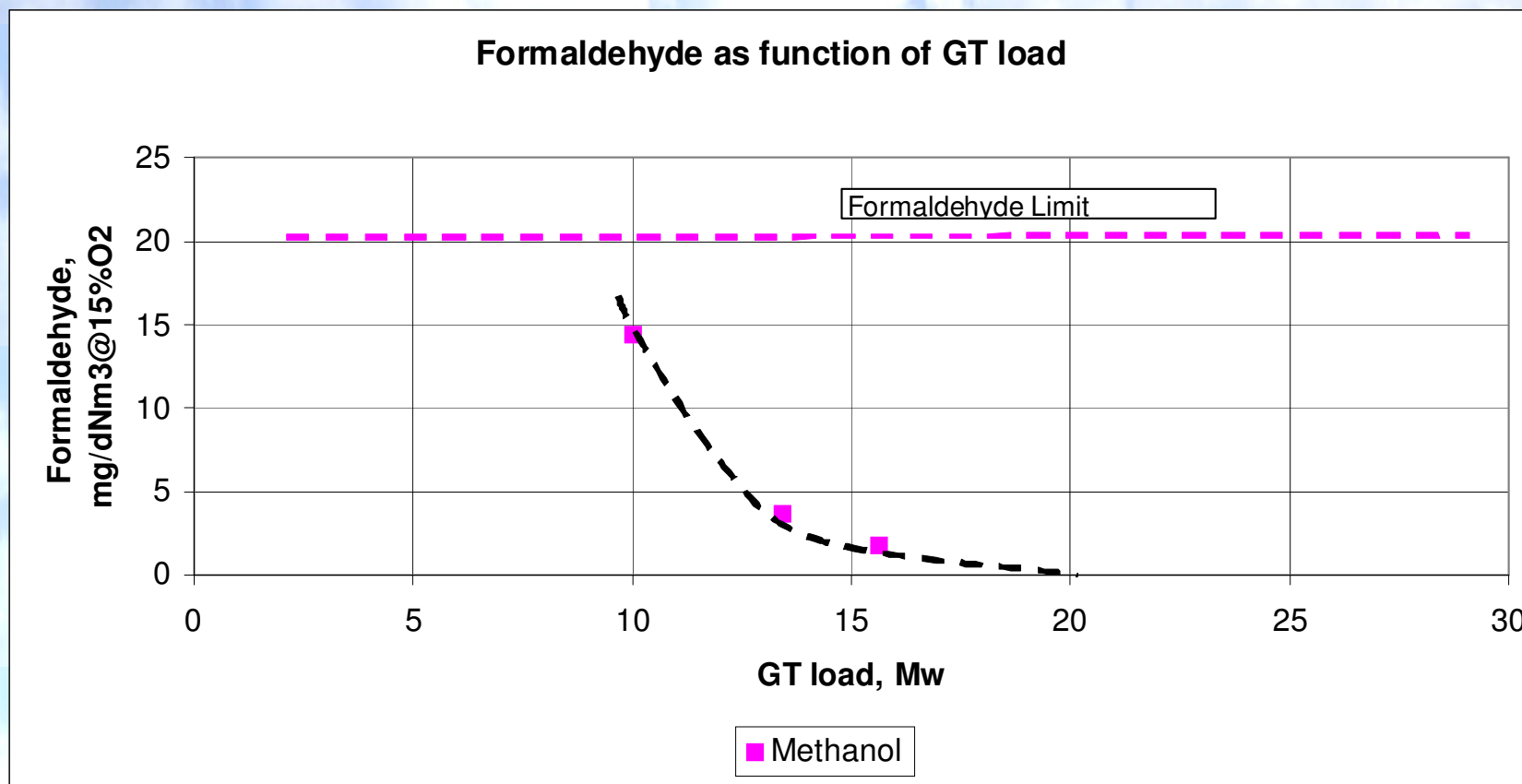
Methanol Test Results



Methanol Test Results



Methanol Test Results





Methanol Test Results

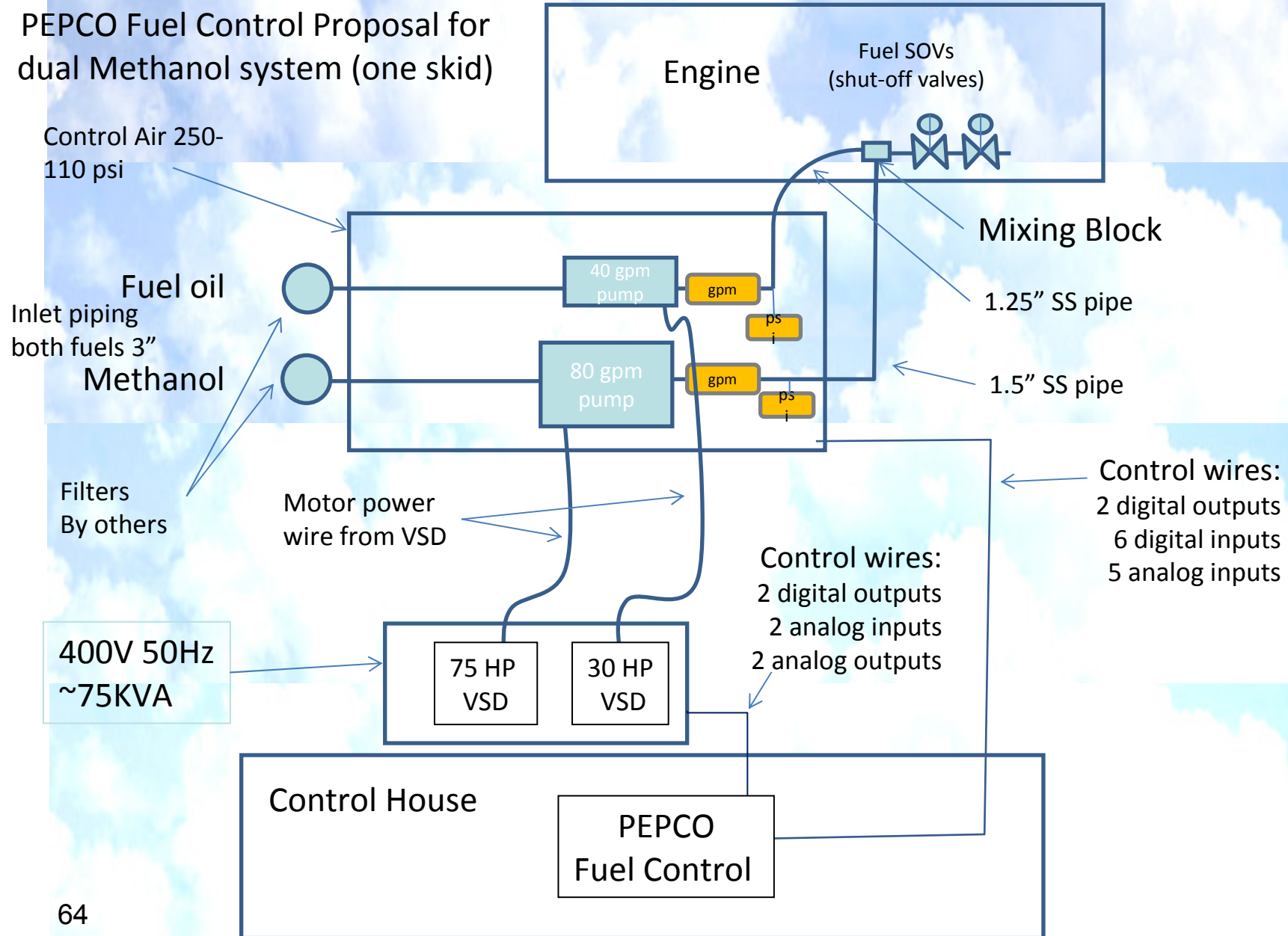
GT Load, Mw	NO _x , mg/dNm ³ @15 %		CO, mg/dNm ³ @15 %		Particulates mg/dNm ³ @15 %		SO ₂ , mg/dNm ³ @15 %	
	LFO#2	Met	LFO#2	Met	LFO#2	Met	LFO#2	Met
22.5	372.7		23.0		12.59		50	
16.0	296.9	71.2	43.9	107.4	13.28	1.28	50	0
13.6	269.0	64.5	63.4	164.4	13.78	1.36	50	0
10.0		56.5		306.7		1.56		0
9.0	224.0		132.0		36.37		50	

NEXT PHASE

- **RESTORE CAPACITY**
- We need to double the fuel flow
- We need to open the bottle necks:
 - High Pressure Pumps (replaced by external pumps)
 - Modulating valve (replaced by VSD)
 - Pressure & Dump valves (internal strainer replaced)
 - Spraying nozzles (replaced from Excello nozzles to Delevan)
- **Two phase Test** (In Eilat)
 - Run a short term test to check feasibility of such a system and validate performance & low emissions (2-3 weeks)
 - Run a long term test to gain operational experience and confidence in the system (2-3 years, 1500-2000 hrs each year)

Restoring Capacity – fuel control & external pumps

PEPCO Fuel Control Proposal for dual Methanol system (one skid)

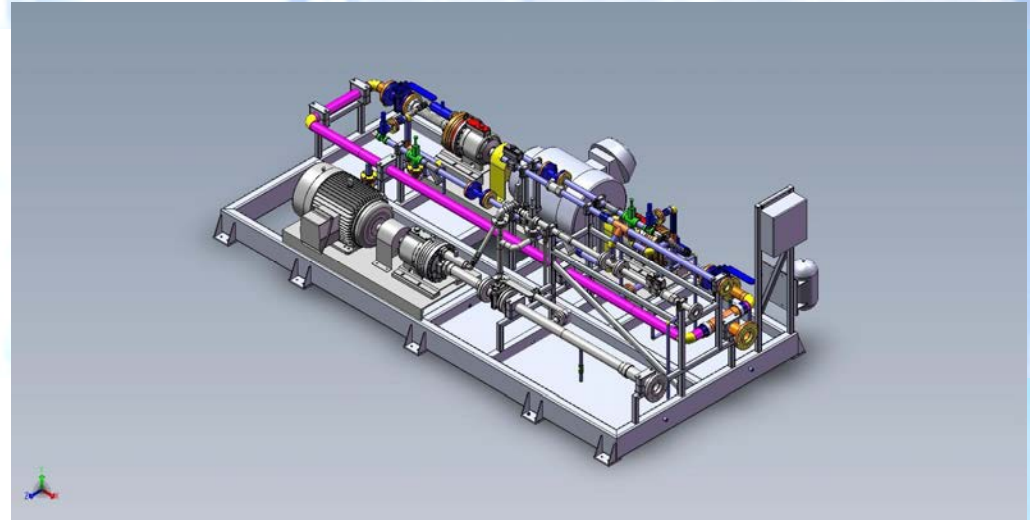


Eilat test – restoring capacity

Replacing nozzles to Delevan high flow •

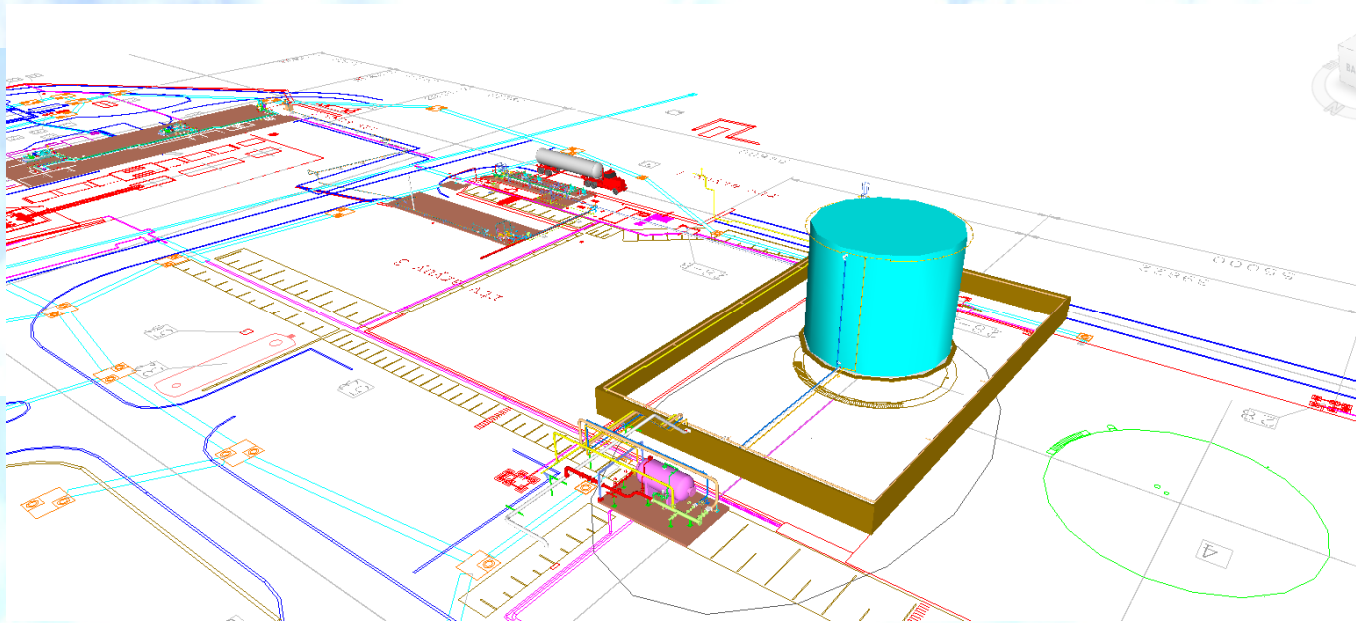


Adding external high pressure pumps

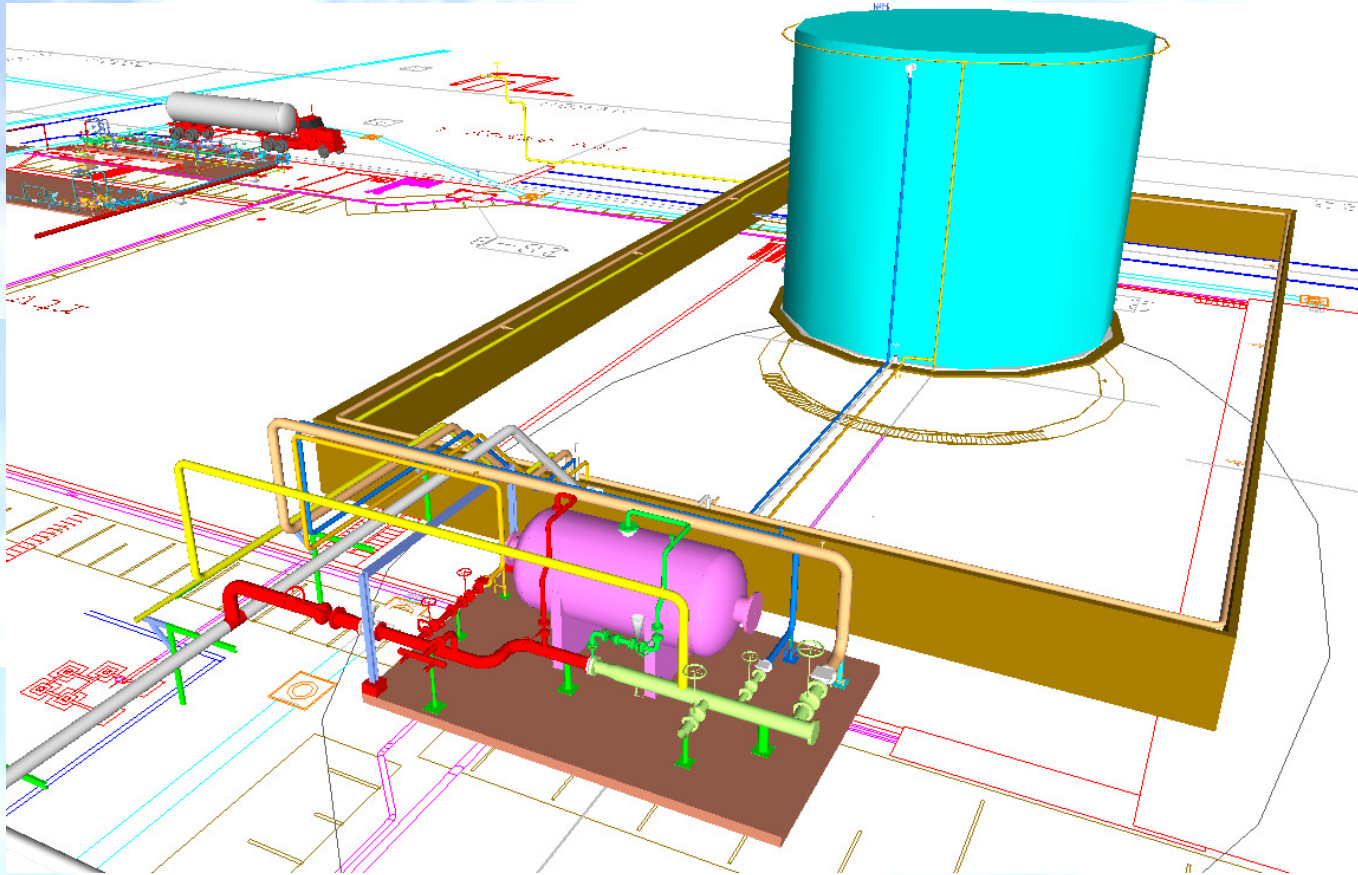


Adapting fuel unloading and storage sytem

- New unloading piping
- Tank adaptation – floating roof



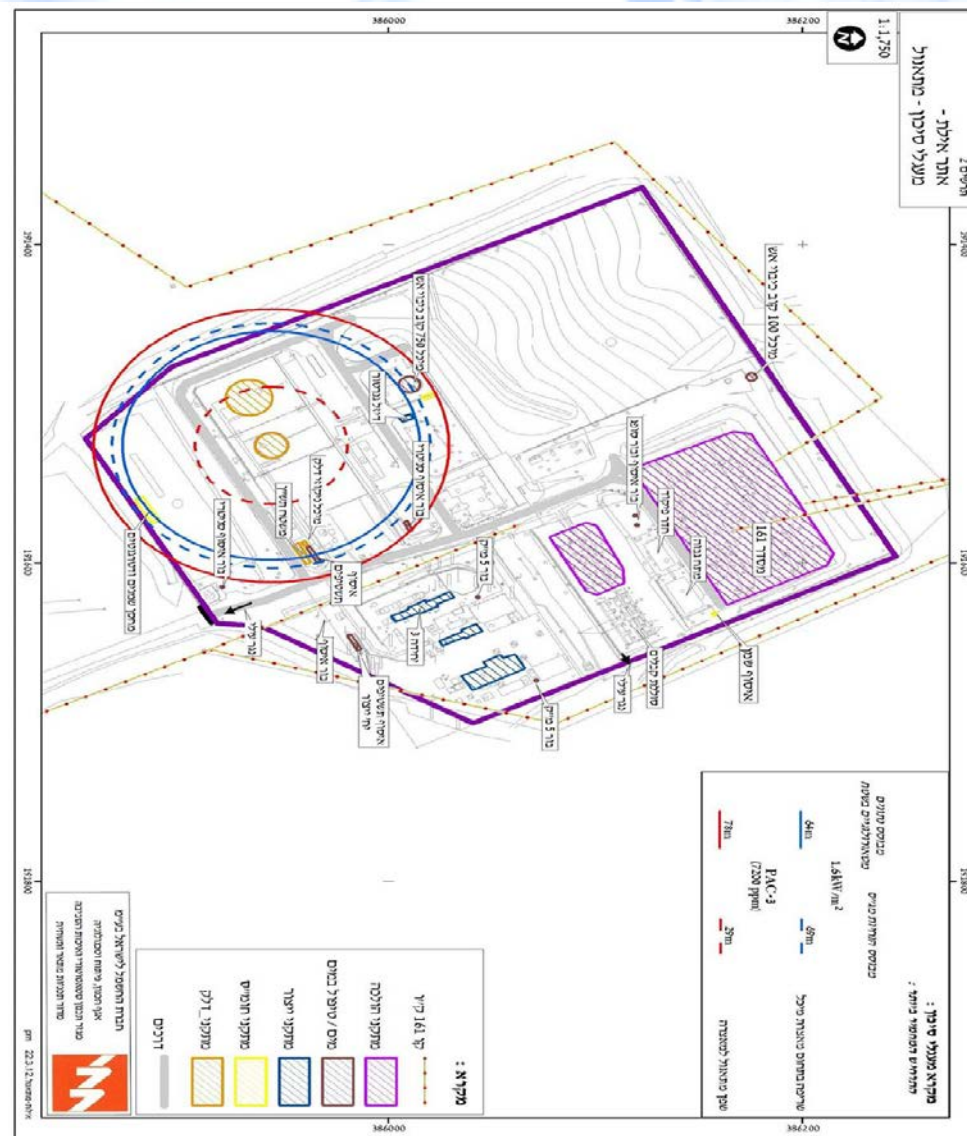
Adapting fire fighting system



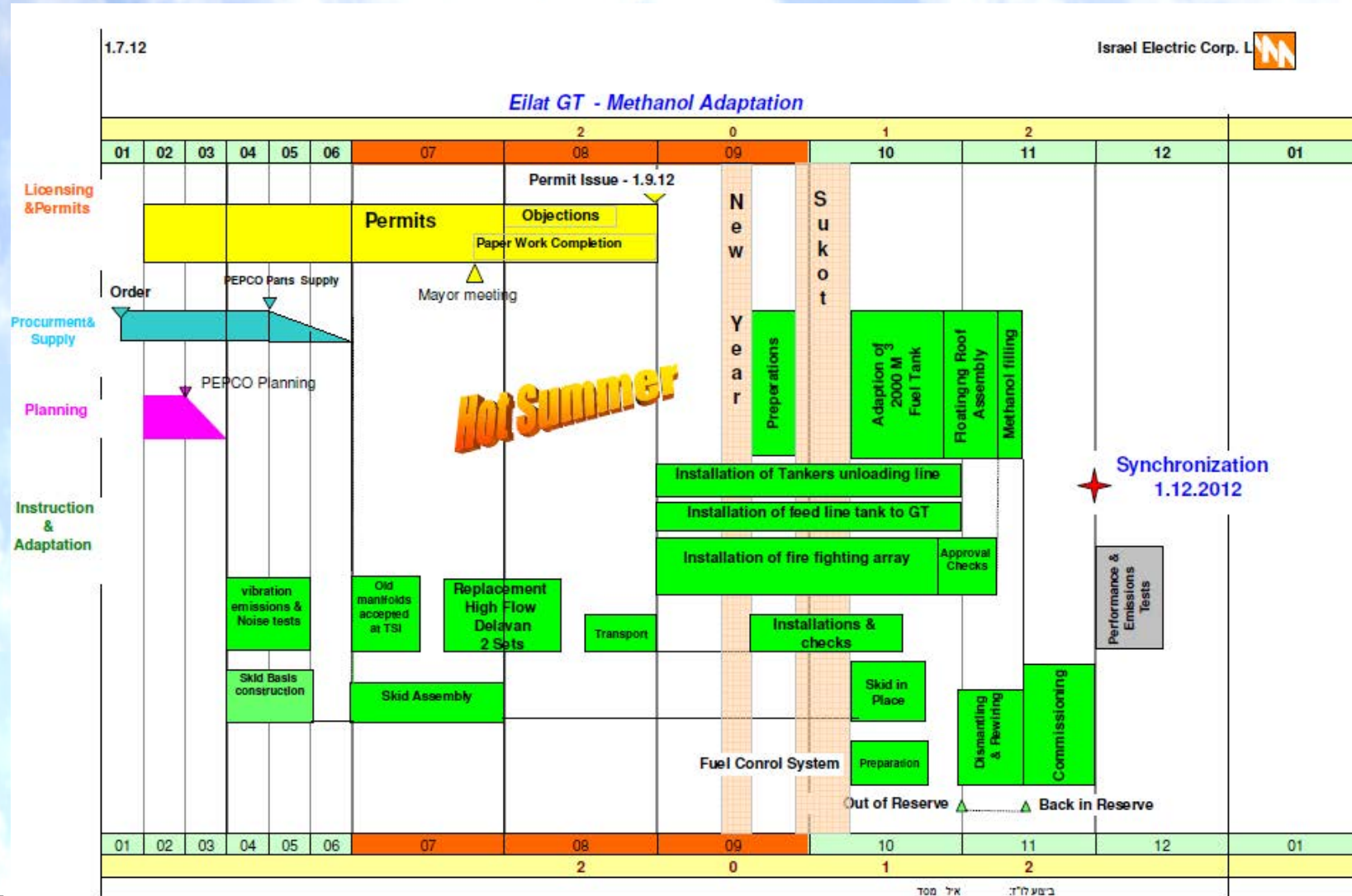
Fuel unloading platform



Danger zone analysis



Time Schedule





Long Term Methanol Firing Modification in Eilat

The IEC in cooperation with Dor Chemicals are in advanced stage of the project converting FT4C TWIN PAC 50 MWe GT Unit in Eilat to methanol firing.

The target is to collect long term data of operating the GT on methanol, which is scheduled to start later this year.



Summary

The results presented here clearly show that with minor low cost fuel system retrofit methanol firing leads to significant **NO_x**, **SO₂** and **particulates** emission reduction while similar facilities performance characteristics are preserved.

We believe that the conclusions of the present work are general and can be applied to other boilers and gas turbines as well.





The Israel Electric Corp.



Thank you!