Final Summary of ICCR Source Work Group Meeting
May 22, 1997
Stationary Combustion Turbine Work Group

DRAFT

I. Purpose

The main objectives of the meeting were to finalize the Turbines Technology Workshop issues, obtain current status of each task group, and discuss HAP emissions from natural gas-fired combustors.

II. Location and Date

The meeting was organized by the US Environmental Protection Agency (EPA) and was held at the Regal University Hotel, 2800 Campus Walk Avenue, Durham, NC. The meeting took place on May 22, 1997.

III. Attendees

Meeting attendees included representatives of the OAQPS Emission Standards Division, trade associations, and state agencies. A complete list of attendees, with their affiliations, is included as Attachment I.

IV. Summary of Meeting

The meeting consisted of discussions and presentations between WG members on selected issues which are listed below. The meeting also included two presentations conducted by non-WG members regarding HAP emissions from process gas and the narrowed list of potential HAPs from combustion turbines. The order of the meeting followed the agenda provided as Attachment II. A bullet point summary of the meeting is presented as Attachment III.

The topics of discussion included the following:

- Discussion of the MACT Primer Presentation
- HAP Emissions from Process Gas
- Turbine Technology Workshop Issues
- Database Task Group Status
- HAP List and Testing Methods for Combustion Turbines
- Testing and Monitoring Task Group Status
- Subcategorization Task Group Status

- HAPs vs. Criteria Task Group Status
- HAP Reduction Task Group Status

Discussion of the MACT Primer Presentation

S. Roy briefly reviewed the MACT Primer presentation given by F. Porter. Some WG members shared their understanding of MACT Standards development requirements with the rest of the WG. Due to the unavailability of MACT Primer presentation, the WG came to a consensus that members who took good notes of the presentation could share their notes with the rest of the WG. Other discussions regarding the MACT Primer concentrated on the definitions and applicability of certain phrases referenced in the presentation. In particular, the definition of “demonstrated,” and the applicability of MACT standards on “existing sources” were debated. S. Roy agreed to discuss with F. Porter the definition and applicability of the term “demonstrated.”

Questions raised by the WG included whether EPA is going to provide all ICCR Work Groups with a guidance procedure for determining MACT standard. Specifically, questions arose regarding how certain operations could be excluded from MACT standards. S. Roy indicated that EPA does not have a set procedure for developing standards which excludes certain operations. This will be source category specific, and the corresponding WG will have to identify the most applicable procedures to determine its MACT floor, potential MACT standards, and exclusions.

HAP Emissions from Process Gas

L. Gilmer of API presented API’s study on HAP emissions from process gas-fired boilers and their applicability to combustion turbines. The study summarizes that HAP emissions from process gas-fired units are minimal. A copy of the presentation by L. Gilmer can be obtained from the EPA TTN bulletin board. It is posted under “Miscellaneous Download Files” as “Gaspres.pds.”

Turbine Technology Workshop Issues

The WG discussed the topics and agenda of the Turbine Technology Workshop. The WG decided that the Technology Workshop will concentrate on emissions from combustion turbine exhausts. Duct burners will not be included in the topics of the workshop. The WG decided to discuss the applicability of duct burners for the reduction of HAP emissions during the September WG meeting. S. Allen will contact duct burner manufacturers to explore the possibilities of them performing presentations at the September WG meeting.

The WG approved the workshop cover letter and decided that there is no need to mail the letter to all members of the ICCR CC and WGs members. The cover letter will be mailed only to local environmental and regulatory agencies, and will be posted on the TTN as an invitation to ICCR CC and WG members.

J. Klein requested from M. Schorr and C. Solt that they submit all names of potential presenters to him by mid-June, 1997. He also indicated that as of yet the workshop does not have any presenters from trade associations. He will contact GRI and EPRI to make sure that they do not have important information which they would like to present during the workshop. The WG reviewed the representation of potential presenters to ensure that the workshop is not viewed as subjective and that no misrepresentations occur. The tentative agenda for the technology workshop will be finalized by the end of June, 1997.

Database Task Group Status

G. Adams discussed and finalized the short list of fields for the population database for turbines. He reviewed with the WG the importance of each identified field, and indicated whether the selected field is available in the ICCR population database or not. The WG members decided to verify the information summarized by G. Adams with their own operations (if applicable). G. Adams also presented the revised source test report checklist which he drafted as a guide for reviewing the gathered HAP source test reports. He warned the WG members that based on his review of several reports, the data quality of each test report varies considerably from one test to another. He suggested that each member spend ample time identifying the information listed on the drafted checklist. B. Richani passed out hard copies of the gathered source test reports for HAP emissions to the WG members for their review. Both the short list of fields and the source test checklist are included as Attachments IV and V, respectively.

B. Richani presented EPA’s progress on reviewing the information gathered in the ICCR Turbines Population Database. This included the progress of the identification of non-turbines records, identification of any potential subcategories, industry classification of the information, reference of currently implemented control devices, and listing of referenced turbine makes and models. B. Richani identified some of the useful information being extracted from the“Combustor Description Field” and the “Fuel Type” field, including turbine make and model, size, fuel type, and application. The criteria used in extracting this information was presented to the group for consensus purposes. It is expected that the information being extracted and assembled from these fields will provide the WG with a complete and detailed description of a small set of turbines which in turn may be used

to categorize the remaining population information. All information and data summaries provided by B. Richani are given as Attachment VI.

HAP List and Testing Methods for Combustion Turbines

The Testing and Monitoring Protocol Work Group (TMPWG) completed a draft of their recommendations to the Stationary Combustion Turbine WG for the list of potential HAPs and test methods. Their recommendations concentrated on natural gas-fired turbines. J. Preczewski presented the recommendations to the WG and explained the criteria used for identifying the listed HAPs. He stressed that these recommendations should be considered a first draft and should represent the full extent of the TMPWG's knowledge and experience with emissions from natural gas-fired turbines. The list of HAPs and corresponding testing methods recommended by the TMPWG is presented as Attachment VII.

Testing and Monitoring Task Group Status

S. Roy discussed two methods used for identifying the potential HAPs expected from turbines. Both methods were applied on the gathered HAP test reports for turbines. The first method identified only HAPs which account for 99 percent of the total HAPs for each individual test, and the second method identified all HAPs with a measured concentration which is higher than the corresponding detection limit. The HAPs lists were categorized by fuel type. Several lists were developed, including one for each of natural gas, diesel, refinery gas, and field gas fuels. The material presented by S. Roy is included in Attachment VIII.

One concern was raised by M. Schorr regarding some of the HAPs concentration levels summarized in the gathered test reports. He presented the results of a recent study conducted by GE which indicated that the ambient concentrations in California for certain HAPs are higher than what is measured in the gathered test reports (Please note that the majority of the HAP test reports gathered for combustion turbines were for sources located in California). He recommended that the WG review these concentrations for their validity.

Subcategorization Task Group Status

M. Schorr indicated that based on the information presented during the MACT Primer, the task group may need to revisit the potential subcategories identified for combustion turbines. These subcategories were presented at the WG's April meeting in San Francisco. He will draft a memorandum of the potential

subcategories for combustion turbines and submit it to WG members before the July WG meeting.

HAPs vs. Criteria Task Group Status

Limited progress was achieved by the HAP vs. Criteria Task Group. The task group has not been able to find a graphical representation of emissions vs. air to fuel (A/F) ratio for combustion turbines. The task group lead, C. Chang, will discuss methods for controlling air to fuel (A/F) ratio with turbine manufacturers. He will also attempt to identify research studies conducted on potential emissions resulting from varying of turbine operating conditions, such as, A/F ratio, load, and combustor type.

HAP Reduction Task Group Status

The HAP Reduction Task Group submitted their draft memorandum discussing operating practices and efficiency improvements. These practices were identified during the WG's April meeting in San Francisco. The task group requested feedback from the WG members regarding the submitted material within one month. The draft memorandum submitted by the task group is included in Attachment IX.

The meeting adjourned at 5:30 pm.

These minutes represent an accurate description of matters discussed and conclusions reached and include a copy of all reports received, issued, or approved at the May 22, 1997 meeting of the Stationary Combustion Turbine Work Group.

Sims Roy

ATTACHMENT I

LIST OF ATTENDEES

Stationary Combustion Turbine Work Group Meeting
April 23 and 24, 1997
List of Attendees

Sims Roy	EPA OAQPS Emissions Standards Division
Greg Adams	Los Angeles County Sanitation District
Sam Allen	Dow Chemical Company
Charles Chang	LA Dept. Of Water and Power
A. J. Cherian	Pacific Gas Transmission Company
Ted Guth	Permitting Regulatory Affairs Consultant
Peter Hill	US Naval Facilities Engineering Svc. Center
John Klein	ARCO Alaska, Inc.
Marvin Schorr	Power Systems Engineering Department
Pete Roberts	Solar Turbines
Gordon Brown	Exxon Chemical
Stan Coerr	Coerr Environmental
Chuck Solt	Catalytica
Derek Furstenwerth	Houston Lighting and Power
Diane McConkey	EPA OMB
Raimund Muller	Siemens Corporation
John Preczewski	New Jersey Department of Environmental Protection
Brahim Richani	Alpha-Gamma Technologies

ATTACHMENT II

MEETING AGENDA

AGENDA
STATIONARY COMBUSTION TURBINE WORK GROUP
May 22, 1997, MEETING IN RTP, NC

8:30 - 8:40 a.m. Welcome

8:40 - 9:00 a.m. Outcome of the CC Meeting

9:00 - 9:30 a.m. Discussion of MACT Floor Primer presentation

9:30 - 10:15 a.m. L. Gilmer - API - Emissions of HAPs from Process Gas Combustion

10:15 -10:30 a.m. BREAK

10:30 -11:00 a.m. Technology Workshop
- Finalizing Agenda
- Handout Materials
- Invitation List
- Other Workshop Issues

11:00 -12:15 p.m. Database Status
- G. Adams: Presentation
- Information Summary of the Population Database
- Database Review methods (including CC guidance, if any)
- Review of turbines operated, owned, or manufactured by WG members
- Review of the remaining turbines in the Population Database
- Draft protocol for reviewing source test reports for inclusion of operating parameters (including CC guidance, if any)
- B. Richani: Population and Emissions Database Presentation
  - Number of Turbines
  - Size Distribution
  - Potential Subcategories
  - Industry Applications
  - Control Devices Referenced
  - List of HAP Pollutants in the Emissions Database with relevant data

12:15 -1:30 p.m. LUNCH

1:30 - 2:00 p.m. J. Preczewski - Test Methods and Monitoring Protocols Work Group - Recommendations to the Combustion Turbines Work Group

2:00 - 2:45 p.m. Testing and Monitoring Task Group
- Narrowing of the List of HAP Pollutants (Rational strategies to reduce HAP list)
- Identify Test Methods to Use
- Identify up to 6 Potential Test Sites with Existing Control Devices
- Discuss Oxidation Catalyst Draft Test Plan

2:45 - 3:15 p.m. Industry Subcategorization
- Comparison with Population Database
- Potential Subcategories Memorandum

3:15 - 3:30 p.m. BREAK

3:30 - 4:00 p.m. HAP vs Criteria Task Group Status

- Progress

4:00 - 4:30 p.m.	HAP Reduction Task Group - Status - Good Operating Practices Memorandum
4:30 - 5:00 p.m.	HAP Emissions from Gas-Fired Combustion Issue
5:00 - 5:20 p.m.	Next Steps - Meetings - Report to the CC
5:20 - 5:35 p.m.	Compose the meeting flash minutes and develop agenda items and schedule for the next Work Group meeting
5:35 p.m.	ADJOURN

ATTACHMENT III

BULLET POINT SUMMARY

Summary of ICCR Source Workgroup Meeting
Stationary Combustion Turbine Workgroup
May 22, 1997

Decisions

- Topics which will be discussed and presented during the technology workshop will not include duct burners. Duct burners will be discussed at a later time during a face to face workgroup meeting. This is tentatively scheduled for the August meeting.
- The workgroup decided that "Turbine ISO Rating" and "Turbine Hours of Operation" are valuable information and should be added to the Turbine Population Database.
- Workgroup members will complete reviewing the HAP test reports by June 24, 1997. The test report check lists will be completed and submitted to G. Adams for compilation by June 24, 1997.
- An agenda item that will be discussed during the July workgroup meeting will be the development of the NSPS in the ICCR effort.
- All modifications and assumptions to the information contained in the population database, such as capacity and capacity units, will be presented to the workgroup.

Next Meeting

- Next WG meeting will be a teleconference on either Tuesday June 24, 1997, or Thursday June 26, 1997, from 1:00 to 3:00 p.m. EST. The final date and call-in number will be posted on the TTN by May 30, 1997.
- Next full (face to face) WG meeting will take place on Thursday July 24, 1997, in Long Beach, CA.

Action Items

- Workgroup members who have taken good notes on Fred's MACT Primer Presentation will share notes with the group.
- S. Roy will discuss with F. Porter if there is a policy on defining what "demonstrated" means.
- M. Schorr and C. Solt will provide J. Klein with names of turbine manufacturers representatives who will be performing presentations during the technology workshop by mid of June.
- J. Klein will send the technology workshop cover letter to S. Roy to be posted on the Technology Transfer Network (TTN) bulletin board.
- B. Richani will copy and distribute the SCONOx test report to the workgroup members.
- J. Klein will check with P. McCarthy and P. Chu whether they have important information which they would like to present during the technology workshop.
- B. Richani will determine why the information contained in the "Facility Contact Person" and "Agency Contact Person" of the population database are similar in some cases.
- G. Adams will revise and resubmit the emissions tests check list based on comments addressed by the workgroup.
- S. Roy will draft a list of what is desired from the Testing and Monitoring Work Group.
- M. Schorr will draft a memorandum of potential subcategorization by the workgroup's June teleconference.
- S. Allen will contact duct burner manufacturers to explore the possibilities of them performing presentations at the August workgroup meeting.
- S. Roy will forward to workgroup members the Account Name and Password

needed to log onto the “TTN Work in Progress” site. This site will be used to download workgroup documents in draft form.

ATTACHMENT IV

SHORT LIST OF DATA FIELDS

SHORT LIST OF DATA FIELDS

NAME OF FIELD	SEE NOTE #	TABLE LOCATION
Facility Information		
ICCR Facility ID		Fuel-Turbine
Plant Name		General Facility-Turbine
Address (Street)		General Facility-Turbine
City		General Facility-Turbine
State Code (FIPS)		Attachment 1
Facility Contact Person		General Facility-Turbine
Facility Contact Phone		General Facility-Turbine
SIC		SIC-Turbine
SCC		SCC Codes; Fuel-Turbine
Combustion Unit Information		
Manufacturer		
Model #		
ISO Rating		
Unit (of Rating)		
Firing or Turbine Inlet Temperature		
Fuel Type (Principal)		Fuel-Turbine
Hours of Operation		Inventory-Turbine
Use Code		
Combustor Device Code		APCD-Turbine*
Year Built		Inventory-Turbine
Year Re-built		
Facility Operating Status		General Facility-Turbine
*Also see "Combustor Description" in Inventory-Turbine table.		

NAME OF FIELD	SEE NOTE #	TABLE LOCATION
Subcategory Information		
Portable Unit		
Offshore Platform Unit		
Cycle Configuration		
Emissions Information		
Combustor ID		Emissions-Turbine
CAS/Pollutant Code		Emissions-Turbine
Control Device Code		APCD-Turbine
Control Device Efficiency		Emissions-Turbine
Method Code		See Attachment 18
APCD Cost		
APCD Waste		
Permit Conditions		Permit Info-Turbine
Supplementally Fired Steam Generators		
Confirmed Information		
Data Checked		

ATTACHMENT V

SOURCE TEST REPORTS CHECK LIST

HAPS and Criteria Pollutant Source Test Checklist

	Source Test Report #____ Date_____	Source Test Report #____ Date_____
BASIC TURBINE INFORMATION		
Manufacturer	_____	_____
Model #	_____	_____
Rating (BHP or MW)	_____	_____
Operating Cycle (Simple, Regenerative, etc.)	_____	_____
FUEL DESCRIPTION		
Fuel Name(s)	_____	_____
Fuel Analysis Summary	_____	_____
Flowrate (or BTU/H, if available)	_____	_____
OPERATING CONDITIONS		
Load (during test)	_____	_____
Water or Steam Injection and/or Ammonia Mass Flowrate	_____	_____
Firing Temperature or Turbine Inlet Temperature	_____	_____
AMBIENT CONDITIONS		
Temperature	_____	_____
Relative Humidity	_____	_____
Barometric Pressure	_____	_____
Altitude	_____	_____
EXHAUST INFORMATION		
Temperature	_____	_____
Flowrate (F-Factor or Measured)	_____	_____
EMISSIONS TEST		
*Criteria Pollutants	_____	_____
HAPS	_____	_____
Oxygen or CO_2	_____	_____
Moisture	_____	_____
Averaging Time	_____	_____
METHODS USED		
CARB	_____	_____
EPA	_____	_____
Other _____	_____	_____
QUALITY CONTROL DOCUMENTATION		
Calibration of Instruments	_____	_____
Specialty Gases	_____	_____
CEMs	_____	_____
Dry Gas Meters	_____	_____
MISCELLANEOUS		
Limits of Detection Reporting	_____	_____
Supplemental Firing Details	_____	_____
YOUR PERSONAL OPINION AS TO REPORT QUALITY	_____	_____

*Attach separate sheet if necessary (ppb, ppm, lb per hr as measured and corrected to 15% O_2 or 12% CO_2, etc., dry).

ATTACHMENT VI

EPA INVENTORY DATABASE PRESENTATION

Stationary Combustion Turbine Controls Summary

05-Jun-97

Fuel Type	Control Device Code	Control Device Description	TotalCount	Total %
DISTILLATE OIL (DIESEL)				
	000	NO EQUIPMENT	1588	90.6%
	028	STEAM OR WATER INJECTION94	5.4%	
	065	CATALYTIC REDUCTION	16	0.9%
	099	MISCELLANEOUS CONTROL DEVICES	13	0.7%
	027	REDUC COMBUST. - AIR PREHEAT	9	0.5%
	046	PROCESS CHANGE	6	0.3%
	022	D.F. AFTERBURN - HEAT EXCH.	4	0.2%
	021	DIRECT FLAME AFTERBURN	3	0.2%
	039	CATAL. OXID-FLUE GAS DESULF	3	0.2%
	016	FABRIC FILTER HIGH TEMP.	3	0.2%
	017	FABRIC FILTER MEDIUM TEMP.	2	0.1%
	024	MODIF FURNACE/BURNER DESIGN	2	0.1%
	001	WET SCRUBBER HIGH EFFICIEN.	2	0.1%
	032	AMMONIA INJECTION	2	0.1%
	101	HIGH EFFICIENCY PARTICULATE AIR FILTER	1	0.1%
	206	LOW NOx BURNERS	1	0.1%
	008	CENTRIF COLL MED EFFICIEN.	1	0.1%
	015	MIST ELIMINATOR LOW VELOC.	1	0.1%
	025	STAGED COMBUSTION	1	0.1%
			1752	
FUEL OIL				
	000	NO EQUIPMENT	14	100.0%
			14	
GASOLINE				
	000	NO EQUIPMENT	16	100.0%
			16	
KEROSENE/NAPHTHA (JET FUEL)				
	000	NO EQUIPMENT	209	84.6%
	065	CATALYTIC REDUCTION	13	5.3%
	028	STEAM OR WATER INJECTION	8	3.2%
	019	CATALYTIC AFTERBURNER	5	2.0%
	008	CENTRIF COLL MED EFFICIEN.	3	1.2%
	032	AMMONIA INJECTION	3	1.2%
	033	CONTRL OF % O2 IN COMB. AIR	2	0.8%
	099	MISCELLANEOUS CONTROL DEVICES	2	0.8%
	047	VAPOR RECOVERY SYSTEM	1	0.4%
	017	FABRIC FILTER MEDIUM TEMP.	1	0.4%
			247	
LANDFILL GAS				
	000	NO EQUIPMENT	24	64.9%
	065	CATALYTIC REDUCTION	5	13.5%
	023	FLARING	4	10.8%
	200	CATALYTIC OXIDIZER (FOR CO AND VOC)	2	5.4%
	028	STEAM OR WATER INJECTION	2	5.4%
			37	
GASOLINE				
	000	NO EQUIPMENT	16	100.0%
			16	

Fuel Type	Control Device Code	Control Device Description	Total Count	Total %
KEROSENE/NAPHTHA (JET FUEL)				
	000	NO EQUIPMENT	209	84.6%
	065	CATALYTIC REDUCTION	13	5.3%
	028	STEAM OR WATER INJECTION	8	3.2%
	019	CATALYTIC AFTERBURNER	5	2.0%
	008	CENTRIF COLL MED EFFICIEN.	3	1.2%
	032	AMMONIA INJECTION	3	1.2%
	033	CONTRL OF % O2 IN COMB. AIR	2	0.8%
	099	MISCELLANEOUS CONTROL DEVICES	2	0.8%
	047	VAPOR RECOVERY SYSTEM	1	0.4%
	017	FABRIC FILTER MEDIUM TEMP.	1	0.4%
			247	
LANDFILL GAS				
	000	NO EQUIPMENT	24	64.9%
	065	CATALYTIC REDUCTION	5	13.5%
	023	FLARING	4	10.8%
	200	CATALYTIC OXIDIZER (FOR CO AND VOC)	2	5.4%
	028	STEAM OR WATER INJECTION	2	5.4%
			37	
NATURAL GAS				
	000	NO EQUIPMENT	1326	76.6%
	028	STEAM OR WATER INJECTION	204	11.8%
	065	CATALYTIC REDUCTION	56	3.2%
	024	MODIF FURNACE/BURNER DESIGN	25	1.4%
	023	FLARING	24	1.4%
	099	MISCELLANEOUS CONTROL DEVICES	23	1.3%
	021	DIRECT FLAME AFTERBURN	12	0.7%
	027	REDUC COMBUST. - AIR PREHEAT	9	0.5%
	019	CATALYTIC AFTERBURNER	9	0.5%
	018	FABRIC FILTER LOW TEMP.	7	0.4%
	032	AMMONIA INJECTION	7	0.4%
	025	STAGED COMBUSTION	5	0.3%
	061	DUST SUPPRESS - WATER SPRAY	4	0.2%
	039	CATAL. OXID-FLUE GAS DESULF	4	0.2%
	051	TRAY-TYPE GAS ABSORB COLUMN	3	0.2%
	033	CONTRL OF % O2 IN COMB. AIR	3	0.2%
	080	CHEMICAL OXIDATION	2	0.1%
	046	PROCESS CHANGE	1	0.1%
	015	MIST ELIMINATOR LOW VELOC.	1	0.1%
	017	FABRIC FILTER MEDIUM TEMP.	1	0.1%
	026	FLUE GAS RECIRCULATION	1	0.1%
	013	GAS SCRUBBER, GENERAL	1	0.1%
	204	LEAN BURN (INCLUDES CLEAN BURN)	1	0.1%
	258	NON-SELECTIVE CATALYTIC REDUCTION	1	0.1%
	064	ANNULAR RING FILTER	1	0.1%
			1731	
NR				
	000	NO EQUIPMENT	9	60.0%
	258	NON-SELECTIVE CATALYTIC REDUCTION	6	40.0%
			15	
		Grand Total:	**3812**	

Count of Models

05-Jun-97

Make	Model	Count Of Model
	5000M	11
	501-K	2
	A6TO	2
	GT-10	2
	GT-20	2
	GT-30	3
	GT-40	3
	GT1400	1
	GT1410	1
	PG6541	1
	T-56	2
		30
ALLISON		
	501	4
	501-K	1
	501-K13	4
	501-KC	1
	501KB	1
	5340	1
	571-K	2
		14
COOPER		
	GMWA-6	4
		4
CUMMINS		
	250H14AB/2A	1
	KTTA-19-G2	1
		2
DETROIT		
	353	1
	4-71N	1
		2
DRESSER CLARK		
	401	1
		1
GARRETT		
	IE831-800	4
		4
GE		
	3002 RA	3
	51W	1
	52R	1
	7000	4
	7821 B	4
	7LM2500 PE	4
	FRAME 3 T	3
	FRAME 5	5
	FRAME 5L	1
	FRAME 5R	1
	FRAME 6	4
	FRAME 7	2
	FRAME 7E	2
	FRAME III	1
	FRAME3 32GR	1
	FRAME3 MODEL G	1
	LM 1600	2

Make	Model	Count Of Model
	LM-500	2
	LM1500	1
	LM1600	5
	LM2500	5
	LM6000	1
	M-3142	1
	M3622R	2
	M3622R-A	8
	M3672 67	2
	M3932R-H	1
	MS-3000	1
	MS-7000EA	1
	MS5000	1
	N FRAME	2
	PB6541B	1
	PG 6531	1
		75
INGERSOL-RAND		
	6-SVG	2
	KVS	2
	PVG-8	2
		6
ORENDA		
	OTF 2R	1
	OTF-270R	2
	OTF-R2	1
		4
PRATT & WHITNEY		
	FT4A-8	2
	FT4A-9	8
		10
ROLLS ROYCE		
	AVON	1
	AVON 101	4
	AVON 76	15
		20
SOLAR		
	100-T15000	3
	1200	7
	CENTAUR	43
	CENTAUR GSC T4500	1
	CENTAUR MODEL H	1
	CENTAUR T-3550	1
	CENTAUR T3000	1
	CENTAUR T3830	3
	CENTAUR T4000	3
	CENTAUR T4500	1
	CENTAUR TAURUS	1
	CENTAUR TYPE H	4
	CENTAUR40-T4700	1
	CS-4000	2
	CSR2000	1
	GS-350	2
	GS350	3
	MARS T-1000	1
	MARS T10000	1
	MARS T12000	1
	MD-1200	3
	PD-4066	1
	SATURN	48
	SATURN 10-T1300	1
	SATURN 1401	1

Make	Model	Count Of Model
	SATURN CSS1200	1

	SATURN GSC 1200	1
	SATURN PHASE IV	1
	SATURN T-1000	4
	SATURN T-1300	6
	SATURN T1001S332	1
	SATURN T1001S444	1
	SATURN T1021	1
	SATURN T1200	2
	SATURN10-T1200	1
	T-1302	2
	T1000	2
	T1200	12
	T4500	1
	T4700	2
	T7002	3
	TAURUS	6
	TAURUS T-70	2
	TAURUS T6500	1
		185
TURBODYNE		
	11D	2
		2
		4
WAUKESHA		
	L3800G	1
		1
WESTINGHOUSE		
	SW501	2
	W171G	2
	W191G	2
	W251B	1
	W251B2	1
		8
	Grand Total:	**368**

STATIONARY COMBUSTION TURBINE POTENTIAL SUBCATEGORIES

FIRST DRAFT

Total Number of Combustion Turbine:	**5242**
Natural Gas-fired	2970
Diesel-fired	2414
Kerosene/Naphtha	327
Landfill Gas	42
Fuel-oil	22
Gasoline	16

(549 turbines are referenced with multiple fuels)

ATTACHMENT VII

LIST OF HAPs AND TESTING METHODS

HAPS Selection and Test Methods for
Natural Gas Turbines

CAS No.	Chemical Name	Test Method(s)
75070	Acetaldehyde	FTIR
107028	Acrolein	FTIR
71432	Benzene	EPA TO-14
92524	Biphenyl	CARB 492
100414	Ethyl Benzene	EPA TO -14
50000	Formaldehyde	CARB 430, FTIR
110543	Hexane	EPA TO-14
67561	Methanol	EPA TO-14, FTIR
108952	Phenol	EPA 0010; CARB 429(m)
100425	Styrene	EPA TO-14
108883	Toluene	EPA TO-14; EPA 0030; CARB 433
1330207	Xylenes (isomers and mixture)	EPA 0030; 18; CARB 422
95476	o-Xylenes	EPA 0030; 18; CARB 422
108383	m-Xylenes	EPA 0030; 18; CARB 422
106423	p-Xylenes	EPA 0030; 18; CARB 422
106990	1,3-Butadiene*	
91203	Naphthalene*	CARB 429; EPA 0010
	Arsenic Compounds*(inorganic including arsine)	EPA Method 29
	Beryllium Compounds*	EPA Method 29
	Cadmium Compounds*	EPA Method 29
	Chromium Compounds*	EPA Method 29
	Cobalt Compounds*	EPA Method 29
	Lead Compounds*	EPA Method 29
	Manganese Compoounds*	EPA Method 29
	Mercury Compounds*	EPA Method 29
	Nickel Compounds*	EPA Method 29
	Polycolic Organic Matter 4*	EPA 0010; CARB 429
	Selenium Compounds*	EPA Method 29

* Existing test data indicate that compound is not emitted in significant quantities from source.
Note: All other HAP compounds are not expected to be emitted from source because basic chemical or physical principles do not favor its existence in source exhaust.

ATTACHMENT VIII

SHORT LIST OF HAPs

METHOD 1

Pollutant List for Natural Gas

Pollutant	**(1) 90% of HAP**	**(2) 95% of HAP**	**(3) 99% of HAP**
Formaldehyde	✓	✓	✓
Acetaldehyde	✓	✓	✓
Acrolein	✓	✓	✓
Benzene	✓	✓	✓
Toluene	✓	✓	✓
Xylene	✓	✓	✓
Ethylbenzene	✓	✓	✓
PAH	✓	✓	✓
Naphthalene			✓
Mercury	✓	✓	✓
Arsenic	✓	✓	✓

Pollutant List for Diesel

Pollutant	**(1) 90% of HAP**	**(2) 95% of HAP**	**(3) 99% of HAP**
Formaldehyde	✓	✓	✓
Benzene		✓	✓
Naphthalene	✓	✓	✓
PAH	✓	✓	✓
Manganese	✓	✓	✓
Nickel	✓	✓	✓
Lead			✓
Chromium			✓

Pollutant List for Refinery Gas

Pollutant	(1) 90% of HAP	(2) 95% of HAP	(3) 99% of HAP
Naphthalene	✓	✓	✓
Chromium	✓	✓	✓
PAH	✓	✓	✓
Nickel		✓	✓
Mercury			✓
Manganese			✓

Pollutant List for Field Gas

Pollutant	(1) 90% of HAP	(2) 95% of HAP	(3) 99% of HAP
Formaldehyde	✓	✓	✓

METHOD 2

Pollutant List for Natural Gas-Fired Combustion Turbines

Pollutant	TotalNumber of Runs	Total Number of Non- Detected Runs	Detection Limit Range	Units
1,3-Butadiene	***6***	***6***	***0.029 - 0.4***	***ppb***
Acetaldehyde	25	1	21.3	ppb
Acrolein	24	13	0.91 - 3.6	ppb
Arsenic	3	0		
Benzene	39	27	1 - 20	ppb
Cadmium	***3***	***3***	***1***	***ug/dscm***
Chromium (VI)	***3***	***3***	***1.54***	***ug/dscm***
Ethylbenzene	21	18	0.2 - 20	ppb
Formaldehyde	56	5	6.5 - 119	ppb
Lead	***3***	***3***	***19.3***	***ug/dscm***
Manganese	***3***	***3***	***19.3***	***ug/dscm***
Mercury	3	0		
Naphthalene	18	3	0.139	ppb
NDMA	***3***	***3***	***0.088***	***ppb***
NMOR	***3***	***3***	***0.061***	***ppb***
PAH	18	0		
Propylene Oxide	***3***	***3***	***11.98***	***ppb***
TMA	***3***	***3***	***0.082***	***ppb***
Toluene	27	6	1 - 20	ppb
Xylene	27	16	0.2 - 40	ppb

Pollutant List for Diesel-Fired Combustion Turbines

Pollutant	TotalNumber of Runs	Total Number of Non- Detected Runs	Detection Limit Range	Units
1,3-Butadiene	***3***	***3***	***7.5***	***ppb***
Arsenic	9	3	6.92	ug/dscm
Benzene	18	11	2 - 110	ppb
Beryllium	6	5	0.0338	ug/dscm
Cadmium	6	3	1.35	ug/dscm
Chromium	9	1	1.35	ug/dscm
Chromium (VI)	6	3	NR	
Dioxins	***3***	***3***	***0.0014***	***ppb***
Formaldehyde	23	6	19 - 119	ppb
Furans	***3***	***3***	***0.00039***	***ug/dscm***
Lead	9	0		
Manganese	5	0		
Mercury	6	2	0.1	ug/dscm
Naphthalene	18	7	0.002 - 0.0213	ppb
Nickel	6	3	3	ug/dscm
PAH	18	2	0.01	ug/dscm
Selenium	***6***	***6***	***0.0352 - 16.4***	***ug/dscm***

Pollutant List for Refinery Gas-Fired Combustion Turbines

Pollutant	TotalNumber of Runs	Total Number of Non- Detected Runs	Detection Limit Range	Units
Benzene	***3***	***3***	***NR***	***ppb***
Cadmium	3	2	1.874	ug/dscm
Chromium	3	0		
Chromium (VI)	***3***	***3***	***NR***	
Manganese	3	0		
Mercury	3	0		
Naphthalene	3	0		
Nickel	3	0		
PAH	3	0		

Pollutant List for Field Gas-Fired Combustion Turbines

Pollutant	TotalNumber of Runs	Total Number of Non- Detected Runs	Detection Limit Range	Units
Benzene	***3***	***3***	***2***	***ppb***
Formaldehyde	3	0		

ATTACHMENT IX

OPERATING AND EFFICIENCY IMPROVEMENTS IDEAS

DRAFT

May 19, 1997

To: ICCR Combustion Turbine Work Group

From: G. M. Brown/A. J. Cherian

This memo documents the work group discussions related to operating practices and efficiency improvements that were held on April 24, 1997 at PG&E offices in San Francisco. The objective of the session was to identify operating practices and efficiency improvements that could reduce HAP emissions and to discuss advantages/ disadvantages associated with each idea. Where possible, data sources and references were identified.

John Klein was our facilitator for these discussions. We captured the work group discussion on flip chart paper and used that feedback to develop this summary memo.

OPERATING PRACTICES

Under the topic of operating practices, the following concepts were discussed at the April 24, 1997 ICCR Combustion Turbine Work Group meeting in San Francisco, CA:

1. Load Management
2. Monitor/Maintain Gas Superheat and Liquids Removal
3. Monitor Air-to-Fuel Ratio
4. Monitor/Control (Water) Steam-to-Fuel Ratio
5. Monitor/Control NH_3-to-NO_x Ratio
6. Monitor Exhaust Gas Temperature Deviations
7. Operator Training

1. Load Management

At sites with multiple turbines, load management is a possible operating practice for reduced HAP emissions. The concept is that the most efficient turbines are operated preferentially to minimize use of turbines at low load. The advantages of this strategy are lower CO and HAP emissions at higher load (higher operating temperature) and reduced fuel consumption (cost savings). While this concept is a

common sense approach to facility operations, it may not be available to some operators (e.g., isolated operators where reliability is critical, such as offshore platform service; load following machines, such as pipeline service or mechanical-drive applications). In general, the work group felt that proper load management was probably already being done where technically feasible because of economic driver.

2. Monitor/Maintain Gas Superheat and Liquids Removal

The concept is to eliminate liquid droplets in gas fuel system through gas preheat or other pretreatment steps (e.g., filtration, refrigeration). This practice reduces heavy hydrocarbons in the fuel and thus, directionally reduces CO and HAPs associated with incomplete combustion. The work group members indicated that this is already a common practice/manufacturer specification for many existing gas-fired turbines (ref: 2). The fuel pretreatment step to elimination of liquid droplets is particularly critical for turbines operating on biogas or landfill gas. A couple of downsides were identified: 1) not applicable to diesel-fired turbines; 2) no HAP data to understand the magnitude of the potential emission reduction. Concern was expressed about shutdown of fuel pretreatment for even short-term emission testing purposes as ramification could be clogged fuel injectors and possibly damage to combustor liner. Overall, the work group believed that an owner/operator would have fuel pretreatment were it was recommended by turbine manufacturer. In other words, there is a strong business driver to do fuel pretreatment where warranted and there is no need to regulate a common sense type issue.

3. Monitor Air-to-Fuel Ratio

In a conventional combustion system (non-low NO_x), the air-to-fuel ratio is fuel-rich close to the point of fuel injection and becomes fuel-lean as you move along the path of the flame. The point of stoichiometric combustion, or maximum/peak temperature, occurs somewhere along the path. Changing air-to-fuel ratios may make the point of peak temperature travel back and forth along the path of the flame, but will neither change the peak temperature nor eliminate regions of improper air-fuel mixing.

In lean pre-mix or low NO_x systems, air and fuel are mixed in stages to try to maintain the combustion temperature below 1950°K (3050°F) to reduce NO_x emissions. Combustion is initiated in a diffusion zone (non lean pre-mix) and then combustion switches over to the lean pre-mix mode once the flame becomes sustainable. To the extent that ideal mixing occurs, products of incomplete combustion (PICs) are reduced.

Under either scenario, the mixing of air and fuel is a design parameter for the manufacturer and does not lend itself to modifications in the field. Altering air-to-fuel ratios in the field without regard to manufacturer's design specifications could result in efficiency losses and even engine malfunction and downtime. Given that the control of the air-to-fuel ratio is a design criteria, air-to-fuel ratio modifications by engine operators in the field are not considered a viable operating practice to control air emissions.

4. Monitor/Control Water (Steam)-to-Fuel Ratio

The addition of water or steam to the flame zone is a common NO_x emission control technique for combustion turbines. While NO_x emissions can be reduced as much as 70% through reducing peak flame temperature, this technique directional increases CO/VOC, and correspondingly HAP emissions. As more and more water/steam is added to the combustor, a point is reached where CO emissions increase sharply. This "knee of the curve" is depend on turbine firing temperature and is a useful tool to defining appropriate water/steam injection levels. (ref: 2). While HAP data are very limited, the work group believed HAP emissions followed the CO/VOC curves as a function of water or steam injection rate. (NOTE: CHUCK SOLT WAS TO FOLLOW-UP HERE AND PROVIDE ADDITIONAL DATA/ REFERENCE MATERIAL.)

In essence, there is a key tradeoff between NO_x emission reduction and CO, VOC, and HAP emissions as a result of the degree of combustion completeness. Any effort to reduce water (steam) injection to reduce HAP emissions, would likely require repermitting of facilities to allow higher NO_x emissions. Another issue is that power production, particularly associated with steam injection, would be negatively impacted, and thus incur an economic debit. In summary, an opportunity may exist to optimize water (steam) injection based on an understanding of the NO_x and CO/VOC/HAP emissions tradeoffs.

5. Monitor/Control NH_3-to-NO_x Ratio

The monitoring and control of NH_3-to-NO_x (molar) ratio was discussed in the context of minimizing NH_3 emissions and thus downstream ambient ammonium nitrate and sulfate formation which contribute significantly to fine particulate matter ($PM_{2.5}$) levels. Although it was recognized that NH_3 is not a hazardous air pollutant, per the

1990 CAAA Title III list of 189, the proposed National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ is a major issue. Thus, NH_3 emissions from turbine NO_x control systems, such as Selective Catalytic Reduction, are a consideration. While NH_3 emissions are addressed in many state permits, NH_3 emission monitoring methods are still in the early stage of development. Monitoring and/or control of NH_3 would have to rely on the NH_3 feed system (feed forward system), rather than stack monitoring (feedback system).

6. Monitor Exhaust Gas Temperature Deviations

Monitoring of exhaust gas temperature deviations was discussed as a practice to diagnose fuel maldistribution (due to dirty or unbalanced fuel nozzles) which could lead to poor fuel spray pattern and thus incomplete combustion. The work group felt that this was already a common practice on turbines with annular or can annular combustors, in accordance with manufacturers recommendations. (This practice is not applicable to single silo type combustors.) The impact on HAP emissions is not known.

7. Operator Training

The last idea that the work group discussed was operator training. The group was aware of the precedent that has been established in other MACT standards (e.g., Municipal Waste Combustors) and other CAA regulation (40 CFR 60, Appendix F dealing with continuous emission monitors). In addition to difficulty establishing link to reduced HAP emissions, the group believed that it had limited usefulness to combustion turbines because of:

1. minimal operator involvement in many gas turbine operations, particularly remote units;
2. the high degree automation, providing minimal 'knobs' to operate; and
3. unlike MWC operations, there is usually little fuel variability in turbine operations.

EFFICIENCY IMPROVEMENTS

Under the efficiency improvements topic, the following three concepts were discussed:

1. Turbine Modifications;
2. Addition of a Regenerator; and
3. Conversion to Gas Fuel.

1. Turbine Modifications

One approach to improve efficiency may be to upgrade or modify mature turbine models to incorporate newer technology and design features. Turbine upratings, to increase power output and improve efficiency, are generally market-driven and generally involve minor design modifications. Cooling air conservation, component matching, improved aerothermodynamics, and small turbine inlet temperature increases can achieve a few percent increase in output with a slight improvement in heat rate (ref: 3). Larger efficiency improvements will need more extensive design modifications, such as increasing compressor pressure ratio and mass flow, and/or relatively large increases in firing temperature.

The major advantages of turbine modifications are that it provides higher output power and a more efficient heat input rate. Heavy frame machines can get about a 50 to 60 percent output increase and about a 15 percent improvement in heat rate, while aero-derivatives are limited to about a 10 percent output increase and about a two to three percent heat rate improvement over their life time. Changing/upgrading fuel nozzles may result in efficiency improvements of above three percent in some applications. A higher firing temperature will likely result in less products of incomplete combustion, such as CO, VOC and HAPs, but could result in higher NO_x emissions.

The major disadvantages of turbine upgrades/modifications include cost-benefit implications for units that do not experience heavy utilization, existing air permit limits for NO_x emissions, triggering federal NSR/PSD review, and triggering NSPS applicability if reconstruction costs exceed a specific threshold. An improved heat rate may mean less fuel consumption or more power for the same fuel consumption rate but, if the firing temperature is higher, it could result in higher NO_x emissions. The increase in NO_x emissions may exceed existing permit limits or could trigger NSR/PSD thresholds.

While higher firing temperatures will likely result in less CO, VOC and HAPs, NO_x emissions will likely increase. Turbine modifications to increase power output and improve efficiency may not have an overall air quality benefit and therefore this approach is not being considered as an across-the-board recommendation for the combustion turbine source category.

2. Addition of a Regenerator

A regenerator is used to capture exhaust heat and to transfer this heat to the incoming air downstream of the compressor and upstream of the combustor. By capturing useful heat from exhaust that would otherwise be vented to the atmosphere, a regenerative cycle improves the thermal efficiency of a turbine. This results in lower ICCR fuel consumption for a given power output. Higher primary combustion zone temperatures will likely lead to less CO, VOC and HAP emissions, but may result in higher NO_x emissions.

The addition of a regenerator will not be a practical option for turbines with high compressor pressure ratios. The higher pressure ratios will result in higher compressor discharge temperatures and if it is higher than the heat recovered via the regenerator, then the recovered heat will result in cooling the combustor inlet air resulting in a reduction of thermal efficiency. The increased pressure drop will also reduce power output. Age will increase the air leakage potential leading to further efficiency drops. Some cycles/configurations do not lend themselves to conversion to a regenerative cycle. Additionally, there could be space and cost considerations that make this option infeasible or cost prohibitive.

Given that the addition of a regenerator may not be a viable option for a large number of units, cycles and configurations, this option is not being recommended for further consideration.

3. Conversion to Gas Fuel

The outcome of the work group discussion was that efficiency improvements resulting from the conversion of liquid fuel to gas fuel may not be significant, less than one percent, especially if compressed gas is not available.

Natural gas produces nearly two percent more output than does distillate oil due to the higher specific heat in the combustion products of natural gas. Within design constraints, gas fuels with lower heating value than natural gas could increase output and efficiency, while higher heating value fuels, such as refinery gas, could result in lower output and efficiency than that obtained from natural gas (ref: 4).

The availability of gas fuel is also a factor at some locations. However, depending upon the fuel quality, HAP generation from gas fuels may be less than that from liquid fuels. A capital investment will be required to make the conversion. The economics of the market place, however, may favor liquid fuels.

While there is the potential for lower HAPs if a turbine is converted from liquid fuel to clean gas fuel, the insignificant efficiency improvements and market place factors, such as availability and cost, do not justify recommending this option as an across-the-board requirement for all units in this source category.

References:

1. Walsh, E. J., GE paper GER-3435, "GE Gas Turbine Multiple - Combustion Systems".
2. Wilkes, G., GE paper GER-3942, "Gas Fuel Clean-up Systems Design Considerations for GE Heavy Duty Gas Turbines".
3. Gas Turbine World, 1996 Handbook, Section 2, New Designs and Updates.
4. Brooks, Frank J., "GE Heavy-Duty Gas Turbine Performance Characteristics", 39th GE State-of-the-Art Technology Seminar, August 1996.

EVGBM034.DOC