

# KSC ENVIRONMENTAL CHECKLIST

1. PROJECT TITLE: Hypergolic Propellant Destruction Evaluation		2. PROJECT NO.: Delivery Order #029	
3. PROJECT LOCATION: <input type="checkbox"/> KSC <input checked="" type="checkbox"/> CCAFS <input type="checkbox"/> PAFB <input type="checkbox"/> OTHER		4. FACILITY NAME/NO.: Space Launch Complex 17 & Fuel Storage Area 1	
5. REQUESTOR/PROJECT LEAD: <u>Chuck Griffin</u> ORG/MAIL CODE: <u>KT-A2</u>		6. PHONE NO.: 321-867-6225	
7. PREPARER OF CHECKLIST: <u>Kurt Kessel</u> ORG/MAIL CODE: <u>KT / ITBINC</u>		8. PHONE NO.: 321-867-8480	
9. PROJECT DESCRIPTION: <i>(Provide site plans, maps, etc. as separate attachment(s))</i> This project is a collaborative effort between Air Force Space Command (AFSPC), Space and Missile Center (SMC) and NASA to evaluate and demonstrate microwave destruction technology proven by AF Research Laboratory and Cha Corporation for the treatment of waste hypergolic rocket fuels.			
10. a-r. Check the appropriate box (Yes, No, Undetermined) to identify if any component of the proposed project (including, but not limited to: construction, installation, demolition, removal, activation or operation) will involve any of the items listed. Use the attached instructions. Provide more specific information for each item marked Yes or Undetermined in the third column.			
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	a. <u>Construction/Modification/Demolition</u> : Constructing, altering, expanding, modifying (other than routine maintenance), or demolishing any building, pavement or structure.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	b. <u>Land Impacts</u> : Land disturbance, soil addition or removal, digging, grading, trenching, alteration or removal of vegetation, equipment/material staging area required, stockpiling and any activity in or near surface water (including ditches and low-lying areas).		
<input type="checkbox"/> Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Undetermined	c. <u>Hazardous Material and Hazardous, Controlled or Universal Waste</u> : Use, storage, generation and/or disposal of any hazardous or toxic material, petroleum products or paint coatings.	Treatment / destruction of hazardous waste	
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	d. <u>Asbestos Containing Material (ACM)</u> : Disturbance of construction material that may contain asbestos (i.e., roofs, walls, ceilings, floor tile, piping insulation, caulk, etc.).		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	e. <u>PCBs</u> : Disturbance or replacement of electrical distribution systems, communication systems, lightning protection, transformers, non-liquid PCB materials or any other items believed to contain PCBs, including paint coatings.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	f. <u>Painting</u> : Initial application or repainting of a facility (interior or exterior), structure or utility.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	g. <u>Paint, Sealant, Caulking Removal</u> : Includes surface preparation such as sandblasting, scraping, water blasting or chemical stripping of existing paint coatings. Specify method.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	h. <u>Dewatering</u> : Use of conventional wellpoints, hydraulic pumps, or other means to transfer groundwater (including water in utility manholes) for project activities including utility trenching, foundation work, roadbed construction, stormwater treatment pond, and borrow excavation.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	i. <u>Stormwater</u> : Construction of new building, pavement, impervious, or semi-impervious surface and/or modification of an existing stormwater system. Give approximate square feet of impervious surface being added.	Sq Ft	
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	j. <u>Drinking/FIREX Water</u> : Installation or modification of potable water system. Include diameter of new water piping if known.	inches	
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	k. <u>Domestic/Industrial Wastewater</u> : Installation or modification of domestic sewer system, including septic tank systems, generation of process wastewater or modification to a system that handles or transports wastewater, including condensate lines, washdown effluent, outfalls, holding ponds and non-point source discharges associated with industrial applications/processes.		
<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Undetermined	l. <u>Air Emissions</u> : Installation or alteration of a stack, scrubber, exhaust fan, vent, generator, fume hood, cooling tower, boiler, halon fire suppression system, HVAC system, refrigeration system; or discharge from painting or sandblasting. Describe emission source.	microwave scrubber technology does vent to the atmosphere	
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	m. <u>Open Burning</u> : Burning of any land clearing debris.		
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	n. <u>Tanks</u> : Construction, modification, or repair of aboveground or underground storage tanks (including piping and/or containment). Give commodity stored and capacity.	gallons	

<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	o. <u>Transformers/Generators</u> : Installation, replacement or repair of transformers, generators, or any other oil-filled equipment. Give capacity.	gallons
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	p. <u>Exterior Lighting</u> : Installation, refurbishment or modification of exterior lighting.	
<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Undetermined	q. <u>Radiation</u> : Generation of ionizing or non-ionizing radiation or use of any radiation source.	<b>Microwave energy induces the decomposition</b>
<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Undetermined	r. <u>Other</u> : Please describe any other aspect of the proposed action that could potentially affect the environment. Use separate sheet if necessary.	

## ENVIRONMENTAL CHECKLIST PREPARATION INSTRUCTIONS

1. **Project Title:** Title of proposed action as it appears on the work order or programming document.
2. **Project Number:** Insert SON, WON, PCN, DBEH, SXHT, MAXIMO or other authorized work identification number, as appropriate.
3. **Project Location:** Check box for applicable installation where work will be conducted. For off-site work, identify location.
4. **Facility Name/Number:** Use the proper name for the facility where work is being conducted and the assigned facility number. If proposed action is not directly associated with a facility, use the closest facility for reference.
5. **Requestor/Project Lead:** List name of individual who has requested the proposed action. If this individual cannot be identified, or no single individual is responsible for submitting the work requirement, then list the person who is most familiar with the proposed action, such as the design engineer or project lead, and their mail code.
6. **Phone Number:** Telephone number of individual identified in #5.
7. **Preparer of Checklist:** List name of individual who completed the checklist and their mail code.
8. **Phone Number:** Telephone number of individual identified in #7.
9. **Project Description:** Provide a brief, complete description of the proposed project. Include size of project and site, proposed uses, and any known plans for the future. Attach additional information including site plans, maps, statement of work, etc.

*Attaching additional information within the eForms software:*

To use the Attach command:

1. Choose File>Attach or
2. Click the paper clip icon to display the Attachments window, then click 'Add'. The Attach dialog appears.
3. Select the file you want then click 'Open'. The file appears in the Attachments window.

Note: If you hold down the Ctrl or Shift keys you can select multiple files at one time.

*Instructions can also be found in the Help within the eForms software.*

**10 a.-r.** The items listed in this section could be included in, or result from, the work that is being proposed. To the best of your knowledge, indicate by checking the applicable box if any of these items could be affected by the proposed work. Check the "UNDETERMINED" box if you are not certain. If further information is required to complete item 10 a.-r., please reference the additional instruction sheet.

**ENVIRONMENTAL CHECKLIST ADDITIONAL INFORMATION AND INSTRUCTIONS**  
**SECTION 10a.-r.**

The following additional information/instructions should be applied to Environmental Checklist Sections 10a.-r.

- a. **Construction:** Some proposed construction activities may not have their scope defined well enough to allow easy identification of potential environmental concerns, and certain facilities and certain types of construction activities have restrictions or constraints that may not be easily identifiable. An example may be disposal of wastes from a construction or demolition project as opposed to waste generated from normal operations and maintenance (O&M) type projects. Types of waste accepted at the KSC Class III Schwartz Road Landfill are listed on the EPB (Environmental Program Branch) web page at <http://environmental.ksc.nasa.gov/permitting/wastePermit.htm>. The proposed project must reflect the proper disposal method in the design specifications to ensure compliance with existing permits.
- b. **Land Impacts:** Areas of major environmental concern associated with this item include the loss of vegetation and disturbance of land that may provide habitat for various types of wildlife. Disturbance of the ground could impact burrowing animals, such as the gopher tortoise. Other issues include the disposal of vegetation from land clearing, underground utilities, archaeological sites, wetlands, etc. If your project includes any type of vegetation removal, land clearing, tree trimming (other than routine landscape maintenance), digging, grading or activity in or near wetlands/surface waters, check yes for this item.
- c. **Hazardous Material and Hazardous, Controlled, or Universal Waste:** A number of items have the potential to adversely effect human health or the natural environment. Consequently, use of these items in the construction and/or operation of the proposed project will require special storage, handling and disposal. Hazardous materials usually constitute items that possess any one or more of the following characteristics: corrosive, flammable, toxic and/or reactive. Should hazardous materials be included in your proposed project, the EPB may be able to identify an acceptable non-hazardous alternative through the Pollution Prevention (P2) program. Wastes generated from use of hazardous materials will generally be classified as hazardous wastes, which require special handling and disposal.
- d. **Asbestos Containing Material (ACM):** Due to the age of many of the buildings and structures on KSC and CCAFS, it is likely that if your project affects an existing facility, ACM may be encountered. If the project involves new construction or is remote from existing structures and/or utilities then it is unlikely that any ACM would be disturbed by your action(s). Many of the existing facilities have already been sampled and the ACM has been identified. Contact the KSC Industrial Hygiene Office at 867-2400 to determine if the project will impact a known ACM source or access the KSC on-line ACM survey database at <http://amis>. If the potential for the presence of ACM exists, sampling must be requested so a determination can be made for all possible sources.
- e. **PCBs:** Polychlorinated Biphenyls (PCB) are chemicals that are primarily found in some types of fluids used in electrical equipment, i.e., electrical transformers, switches, ballasts, etc. Non-liquid PCBs may also be present in older paint coatings, caulking and other materials. Consequently, all projects or jobs that will come in contact with any fluid filled electrical equipment, or non-liquid materials suspected of containing PCBs should include sampling and analysis for PCBs. A current analysis (within six months) must accompany each fluid-containing piece of electrical equipment requiring disposal.
- f. **Painting:** Painting, depending on the method and contents of the paint, can generate hazardous or controlled wastes. Use of paint thinner and chemical stripper typically results in generation of waste requiring special handling and disposal. If known, please indicate if these painting related materials are to be used. If your project includes any painting check yes for this item and include specific information regarding paint contents, other hazardous materials to be used and painting methodology, as applicable.
- g. **Paint, Sealant, Caulking Removal:** Removal of existing paint coatings, sealants and caulking can generate hazardous or controlled wastes. In some cases, old paint coatings containing lead and/or other metals as well as non-liquid PCBs will require specific abatement procedures and special disposal of wastes generated. If your project includes any paint, sealant, or caulking removal activities check yes for this item and include specific information regarding paint contents, other hazardous materials to be used, and paint or sealant removal methodology.
- h. **Dewatering:** If the proposed project will require the pumping of water to support construction activities, a permit may be required. There are a number of variances and quantity thresholds based upon the amount of water being transferred and the area where the water will be discharged. Therefore, if your project requires dewatering, check yes and the EPB will determine permit applicability.

- i. **Stormwater:** Stormwater is an environmental concern primarily due to potential impacts of rainwater runoff from an impervious surface into the surrounding area. An impervious surface prevents stormwater from percolating into the ground. Consequently, the St. Johns River Water Management District (SJRWMD) requires a permit to be obtained and a stormwater management system to be constructed when a large impervious surface is created. The threshold for obtaining a permit varies from 4000 square feet for surfaces specifically supporting vehicular traffic, such as roads, parking lots, stabilized areas, etc., to 9000 square feet for buildings inclusive of all other impervious surfaces. The permit threshold can also be "tripped" by adding to or modifying an existing impervious surface, so do not assume the project will not require permitting if new impervious area is below the above thresholds. If you check "yes", please identify the number of square feet involved.
- j. **Drinking/FIREX Water:** Check yes if the proposed project involves work that would affect a potable water line. Environmental concerns with work that affects water lines are: 1. The disturbance of a water line typically lowers water quality and therefore, requires disinfection and sampling prior to use; 2. Some connections and/or additions to the existing water system require a permit. Supply as much design information as possible relating to potable water system changes (e.g., new vs. extension, pipe diameter, etc.). Permit determinations and applications will be handled by the EPB.
- k. **Domestic Wastewater/ Industrial Wastewater:** Environmental concerns include potential impacts to the operation of the Wastewater Treatment Plant and Florida Department of Environmental Protection (FDEP) permit conditions. New connections and septic tank installations may require permitting, inspection, and/or certification. Therefore, check yes if the proposed project will involve installation of new wastewater sources or in any way affect the existing sanitary sewer system. Industrial wastewater is any water-based waste stream, discharge, wash water, deluge outfall, etc., that would result from conducting an industrial-type operation. The source of this wastewater typically requires permitting and therefore, must be identified to the environmental office as soon as possible. In addition, early environmental coordination could result in the identification of a process alternative that may preclude or minimize the waste stream.
- l. **Air Emissions:** If the project (either during construction or operation) would discharge any substance into the air, other than vehicular or normal construction equipment exhaust, check yes and describe the source of the emission. Some emission sources may require State and/or Federal permitting for both construction and operation.
- m. **Open Burning:** If any land clearing debris will be burned during construction, check yes. The Florida Department of Forestry requires notification in accordance with FAC 51-2 Open Burning. Coordination with the KSC Fire Marshall is also required.
- n. **Tanks:** Any vessel that stores liquids, other than drinking water, must be evaluated for potential environmental effects. Some tanks require registration with the State based upon the quantity and type of material being stored. All tanks must be identified in the tank management program and various containment and piping requirements may apply. If you suspect the involvement of any new or existing tanks, including associated piping or containment, check yes and the EPB tank program managers will identify any regulatory requirements.
- o. **Transformers/Generators:** If any oil-filled equipment is to be modified, replaced or installed, check yes. There are specific handling, removal and waste disposal guidelines to follow as well as Spill Prevention, Control and Countermeasures (SPCC) requirements to be met.
- p. **Exterior Lighting:** Exterior lights at or near Atlantic Coast beaches in Florida have been proven to disrupt sea turtle nesting. Consequently, NASA has developed exterior lighting policies to minimize adverse impacts to threatened and endangered sea turtles that nest on KSC beaches. Should the project include exterior lights, either new or replacement of existing, check yes and the EPB will review the design of your project to ensure compliance with the applicable policies. Typically, exterior lights that are not directly related to a color rendition or explosion proof requirement will be the lowest wattage, low pressure sodium fixtures that meet the needs of your request. Exterior lighting requirements are located on the EPB web page at: <http://environmental.ksc.nasa.gov/projects/documents/ExteriorLightingGuidelines.pdf>
- q. **Radiation:** Various types of mission related equipment has the potential to emit radiation that could effect human health and the well being of other living organisms. Typically, the project/job requestor is aware of the dangers associated with the equipment being constructed, installed, modified or maintained. However, in some cases, work may be requested that would take place within a zone of influence for an existing piece of equipment, thereby requiring shut-down or some other operational constraint. Therefore, if you know the project will involve a radiation source, or is in the vicinity of a potential source of radiation (radar, microwave transmitter, etc.) check yes.
- r. **Other:** If aspects of the proposed project do not fit into any of the above categories, but may have an effect on the natural environment, explain in the space provided. This space should also be used to explain or identify specific aspects of the above items, as necessary. If there is not enough space to adequately explain the item you are describing, please attach an additional sheet and reference a continuation sheet in case they should become separated.

# Microwave Scrubber for destroying hypergolic fuel vapors



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# Microwave Scrubber for Hypergolic Rocket Fuel

Presented at  
UPC Operator Training Seminar

**Dr. Chang Yul Cha**  
CHA Corporation

Kevin Case  
30 CES/CEVV

Brian Pollock  
AFRL/MLSC



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# Defining The Problem

- The loading of liquid propellants used to power and launch rockets produces a nitrogen or helium stream saturated with toxic propellant vapors.
- Propellants being used today include:
  - Dinitrogen Tetroxide ( $N_2O_4$ )
  - Hydrazine
  - Monomethylhydrazine (MMH)
  - Unsymmetrical Dimethylhydrazine (UDMH)



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# Current Technologies

- Currently, the toxic propellant vapors are disposed of using a wet chemical scrubber.
- This scrubber is capable of removing 90-99% of the propellant vapors in the stream.
- The scrubber system creates a toxic liquid waste stream which must also be treated.



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# Microwave-Induced C-NO Reaction

- $\text{N}_2\text{O}_4 \longrightarrow 2 \text{NO}_2$
- $2 \text{NO}_2 \longrightarrow 2 \text{NO} + \text{O}_2$
- $2 \text{NO} + \text{C} \longrightarrow \text{N}_2 + \text{CO}_2$
- Activation energy,  $E_a = 17 \text{ kJ/mole}$  for microwave induced C-NO reaction
- $E_a = 63\text{-}68 \text{ kJ/mole}$  for thermal C-NO reaction



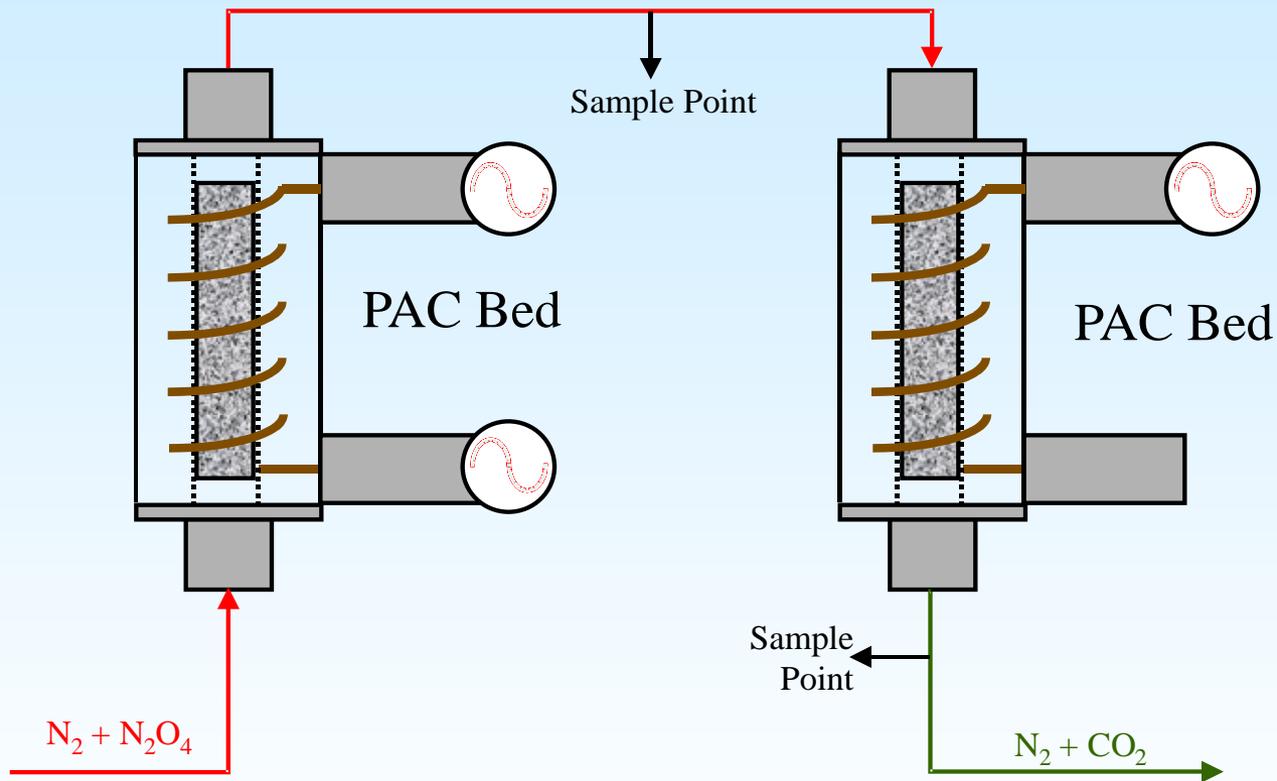
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# Optimization Test Set-Up



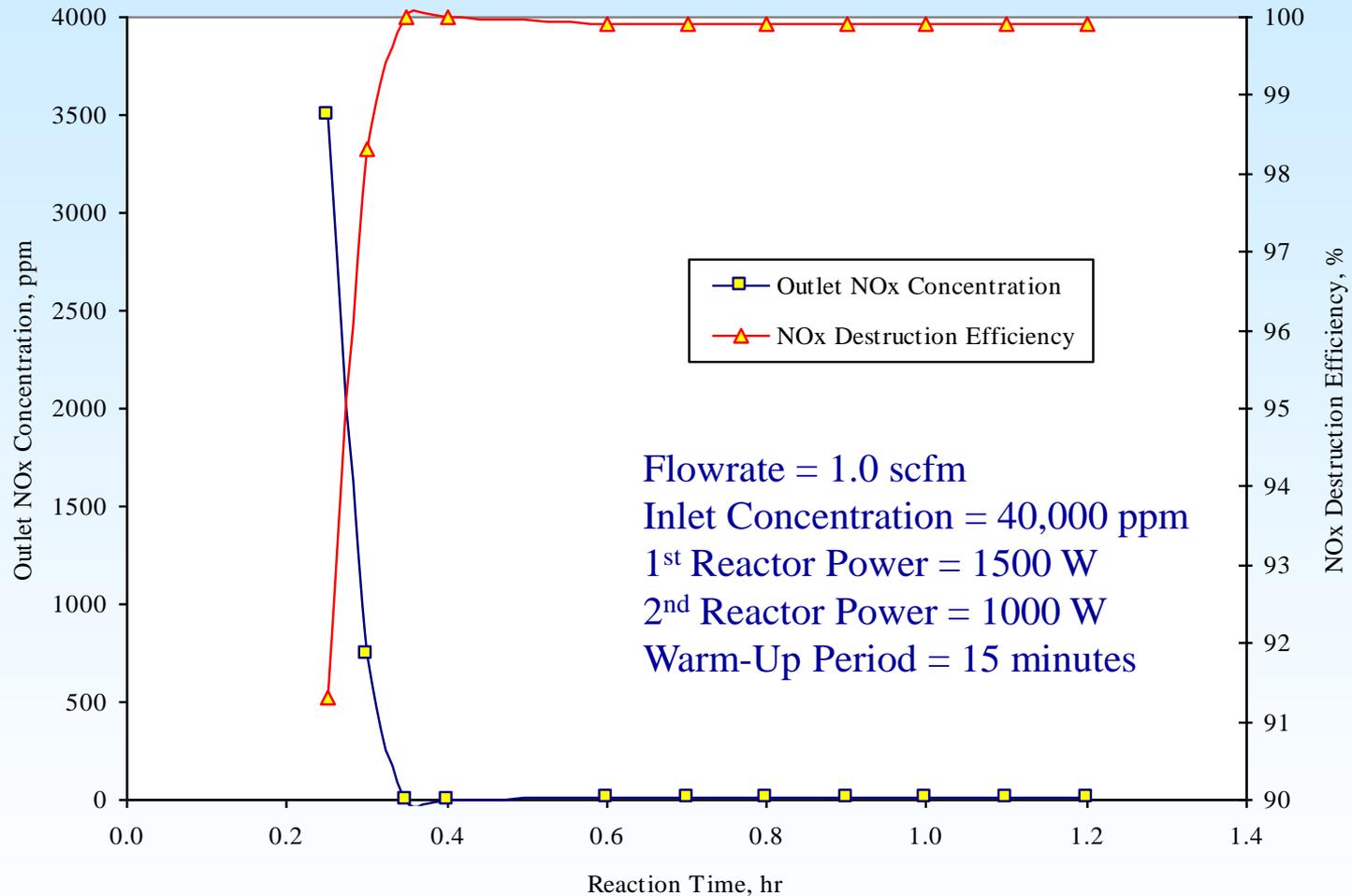
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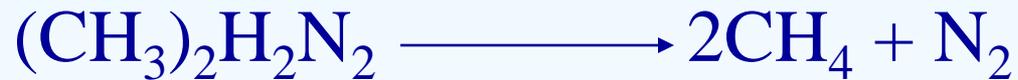
# Typical Experimental Result



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# Decomposition of Hydrazine Fuel over a Carbon Bed by Microwaves



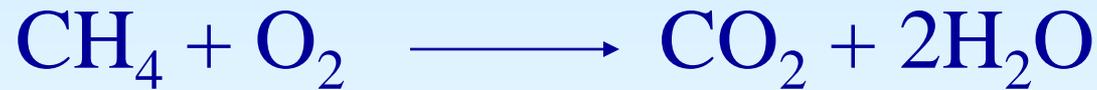
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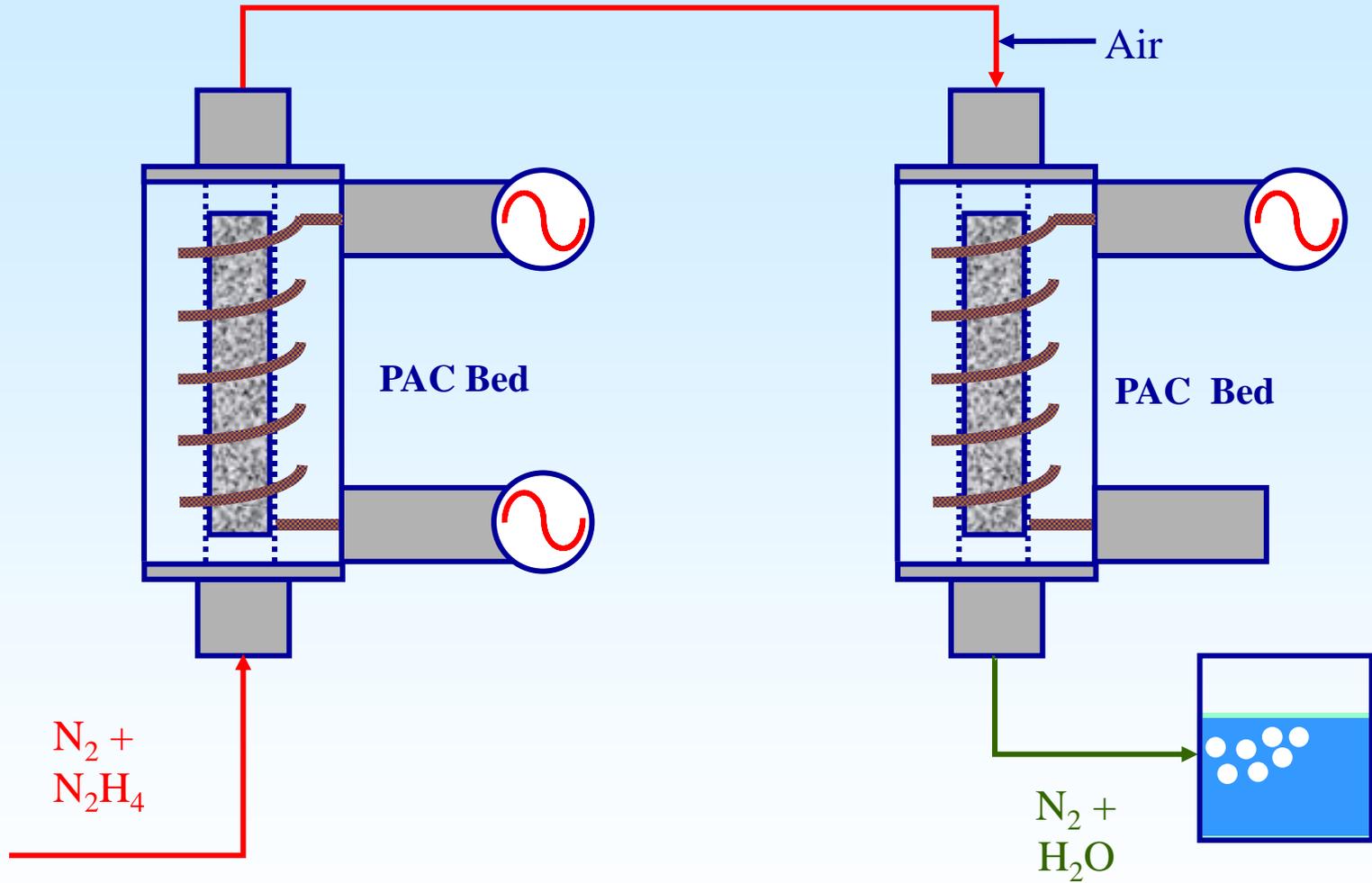
# Microwave-Induced Oxidation in SiC Bed



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# Hydrazine Destruction Apparatus



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# Hydrazine Destruction in a Carbon Bed

N <sub>2</sub> Flow Rate, scfm	1 <sup>st</sup> Reactor Power, W	2 <sup>nd</sup> Reactor Power, W	Pressure Drop, psig	Hydrazine Emitted, g	Amount of Hydrazine Forming Ammonia (%)
1.0	1500	1000	0.8	0	0.001
1.5	1500	1000	1.0	0	0.008
2.0	1500	1000	1.7	0	0.079



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# Fuel Site Field Demonstration



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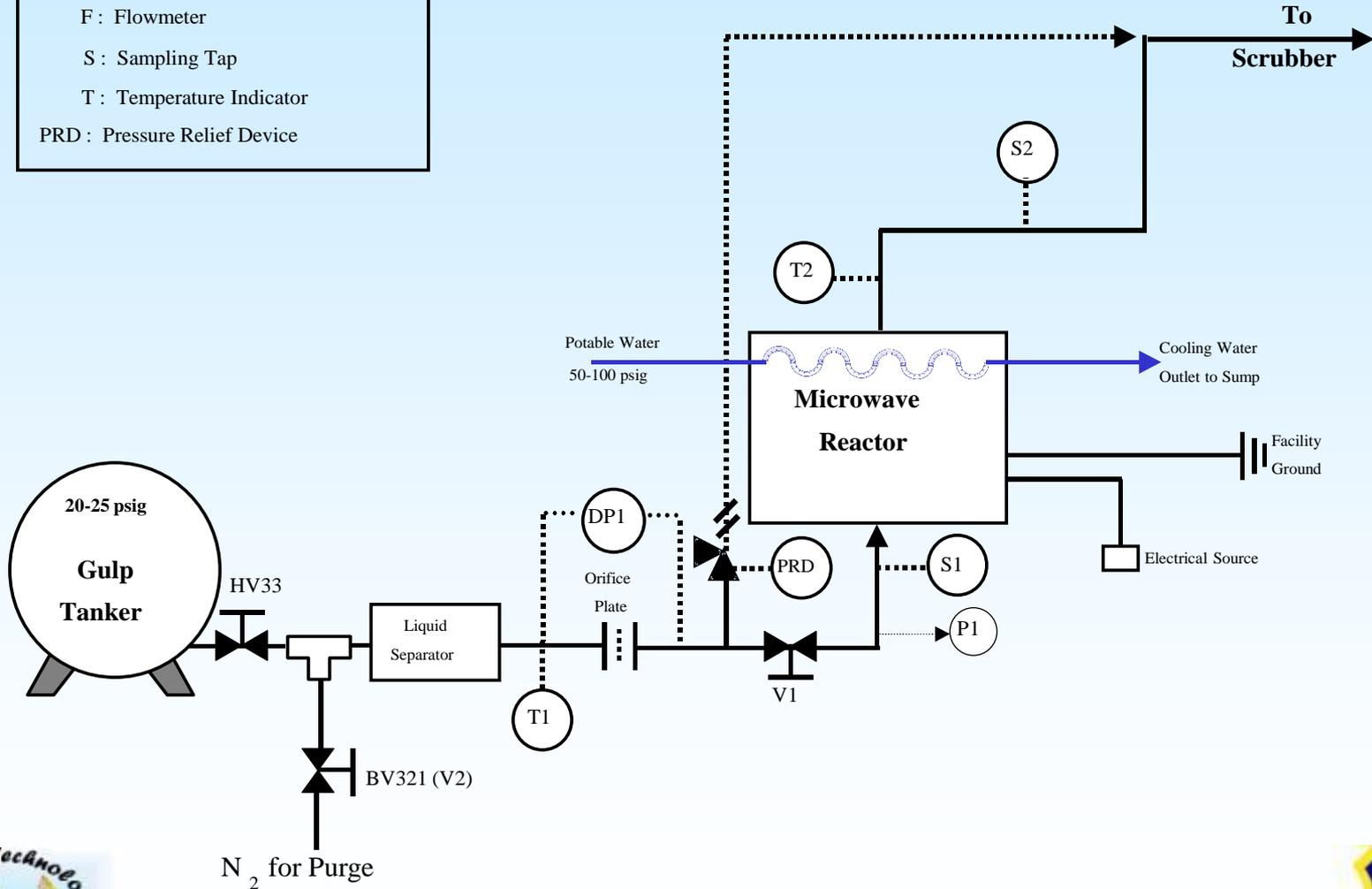


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# Reactor System PFD

P : Pressure Indicator  
 F : Flowmeter  
 S : Sampling Tap  
 T : Temperature Indicator  
 PRD : Pressure Relief Device



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# Reactor In Laboratory



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# Fuel Site Scrubber System



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# Reactor at Fuel Site



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# Summary Fuel Test Results (Aerozine-50 Vapor)

- The Average Inlet Concentration = 11,000 ppm
- The Average Outlet Concentration = 63 ppm
- Microwave Destruction Efficiency = 99.4 %



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# Oxidizer Site Field Demonstration



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# Oxidizer Site Tanker



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# Oxidizer Test Results

- Average Inlet Concentration = 396,000 ppm
- Average Outlet Concentration = 57 ppm
- Microwave Destruction Efficiency = 99.99%
- Percent of NO<sub>x</sub> Destroyed in 1<sup>st</sup> Reactors = 93%



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# Construction of Microwave Scrubber for Destroying of Oxidizer Vapor



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# Microwave Scrubber for Oxidizer Vapor

- Microwave scrubber for destroying waste oxidizer vapor ( $N_2O_4$ ) was constructed and installed at VAFB in August 2006
- 99.95-100% destruction efficiency was achieved in scrubber laboratory tests
- Startup test and safety inspection were completed in January 2007
- 99.94-100% destruction efficiency was achieved during 2-hour startup test



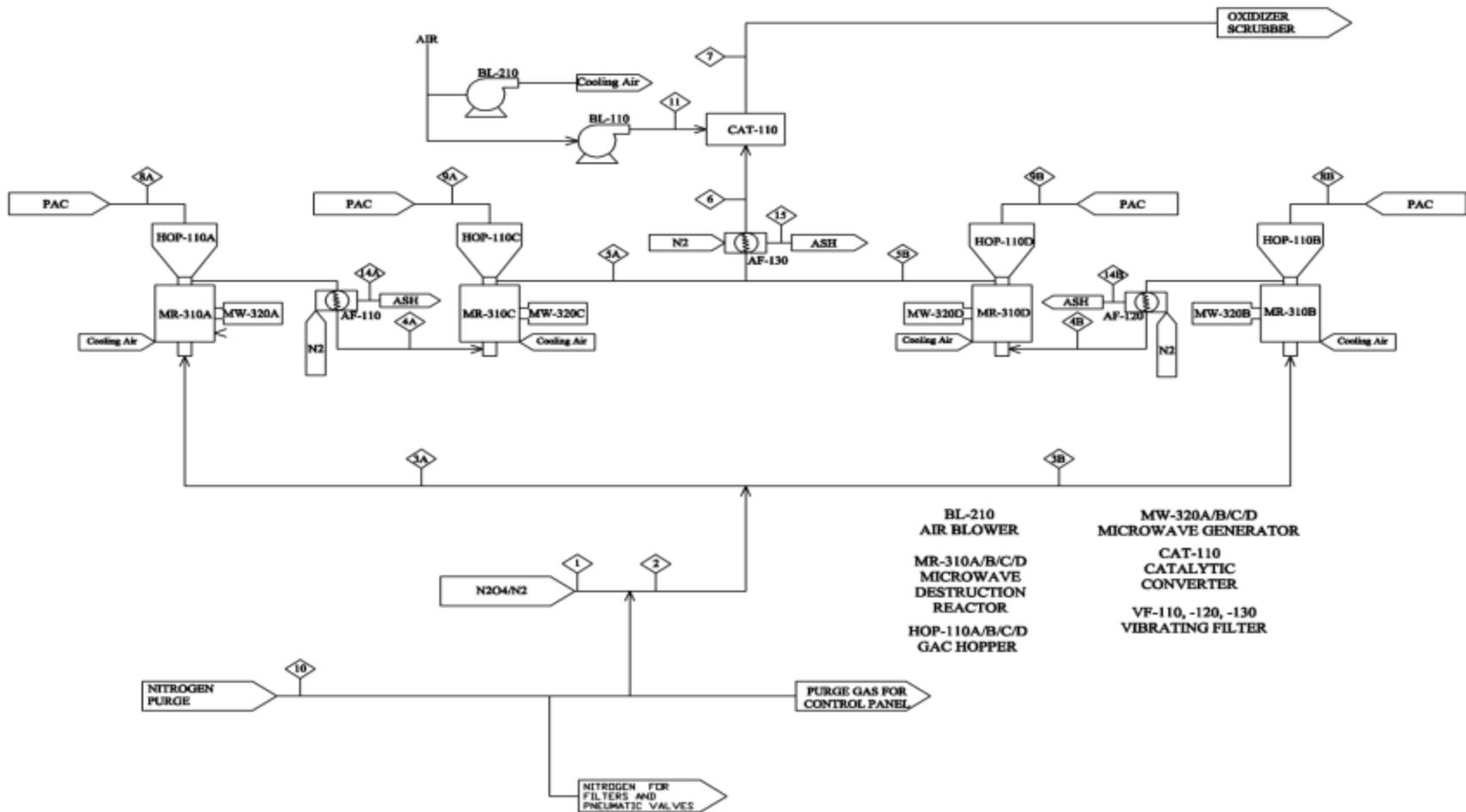
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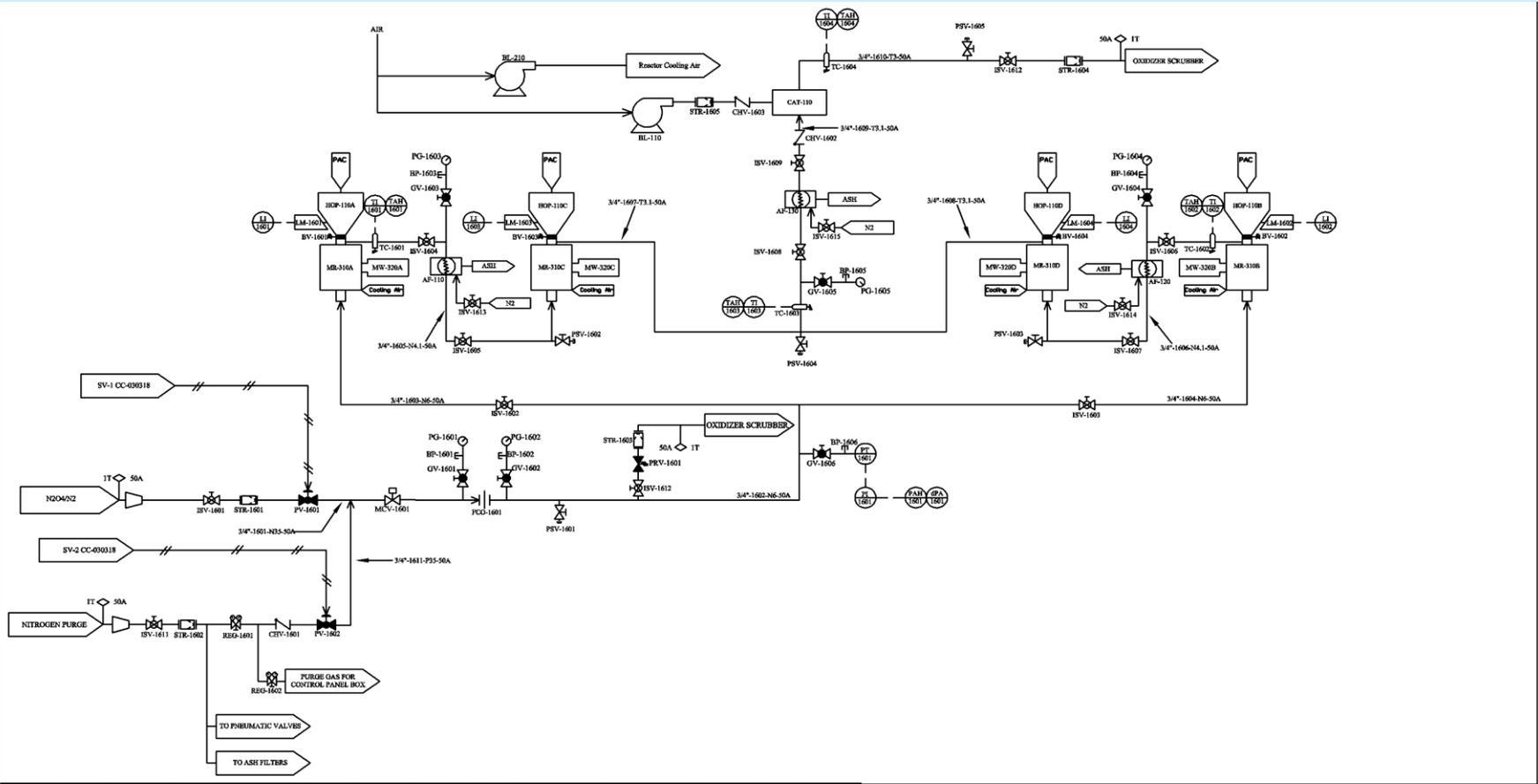


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# Process Flow Diagram





LINE NO.	SIZE	SPEC.	FROM	TO	FLOW (SCFM)	TEMP. (F)	PRES. (PSIG)	LINE NO.	SIZE	SPEC.	FROM	TO	FLOW (SCFM)	TEMP. (F)	PRES. (PSIG)
1601-N35	3/4"	17/50A	N-O <sub>2</sub> FEED	FCO-1601	5.00	85.0	36.0	1608-T3.1	3/4"	50A	1607-T3.1/1608-T3.1	CAT-110	12.56	200.0	3.1
1602-N6	3/4"	50A	FCO-1601	1603-N9/1604-N6	5.00	85.0	6.0	1610-T3	3/4"	50A	CAT-110	OXIDIZER SCRUBBER	12.76	200.0	3.0
1603-N6	3/4"	50A	1602-N6	MR-310A	2.50	85.0	6.0	1611-P35	3/4"	17/50A	NITROGEN PURGE	1601-N35	4.90	85.0	35.0
1604-N6	3/4"	50A	1602-N6	MR-310B	2.50	85.0	6.0	1612-A3.1	1/4"	17/50A	FCO-1602	CAT-110	0.20	85.0	3.1
1605-N4.1	3/4"	50A	MR-310A	MR-310C	6.18	250.0	4.1	1613-A3.1	2"	50A	OMP-210	MR-310A	100.00	85.0	3.1
1606-N4.1	3/4"	50A	MR-310B	MR-310D	6.18	250.0	4.1	1614-A3.1	2"	50A	OMP-210	MR-310B	100.00	85.0	3.1
1607-T3.1	3/4"	50A	MR-310C	1608-T3.1	6.28	250.0	3.1	1615-A2.8	2"	50A	MR-310A	VENT	100.00	90.0	2.8
1608-T3.1	3/4"	50A	MR-310D	1608-T3.1	6.28	250.0	3.1	1616-A2.8	2"	50A	MR-310B	VENT	100.00	90.0	2.8

DRAWN BY: BBV  
 DATE: 12/7/04  
 REVISED BY: BDB  
 DATE: 03/23/06  
 CHECKED BY:  
 APPROVED BY:

**CHA Corporation**

VANDENBERG AFB  
 MICROWAVE OXIDIZER SCRUBBER  
 PIPING AND INSTRUMENTATION DIAGRAM

SIZE	FSCM NO	DWG NO	REV
		CC-040316	7
SCALE		SHEET	1 OF 1



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# Reactor Bank



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# Back Right Corner of Microwave Scrubber



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# Back View of Microwave Scrubber



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# Front View of Microwave Scrubber



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# Electrical Cabinet



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# Microwave Reactor



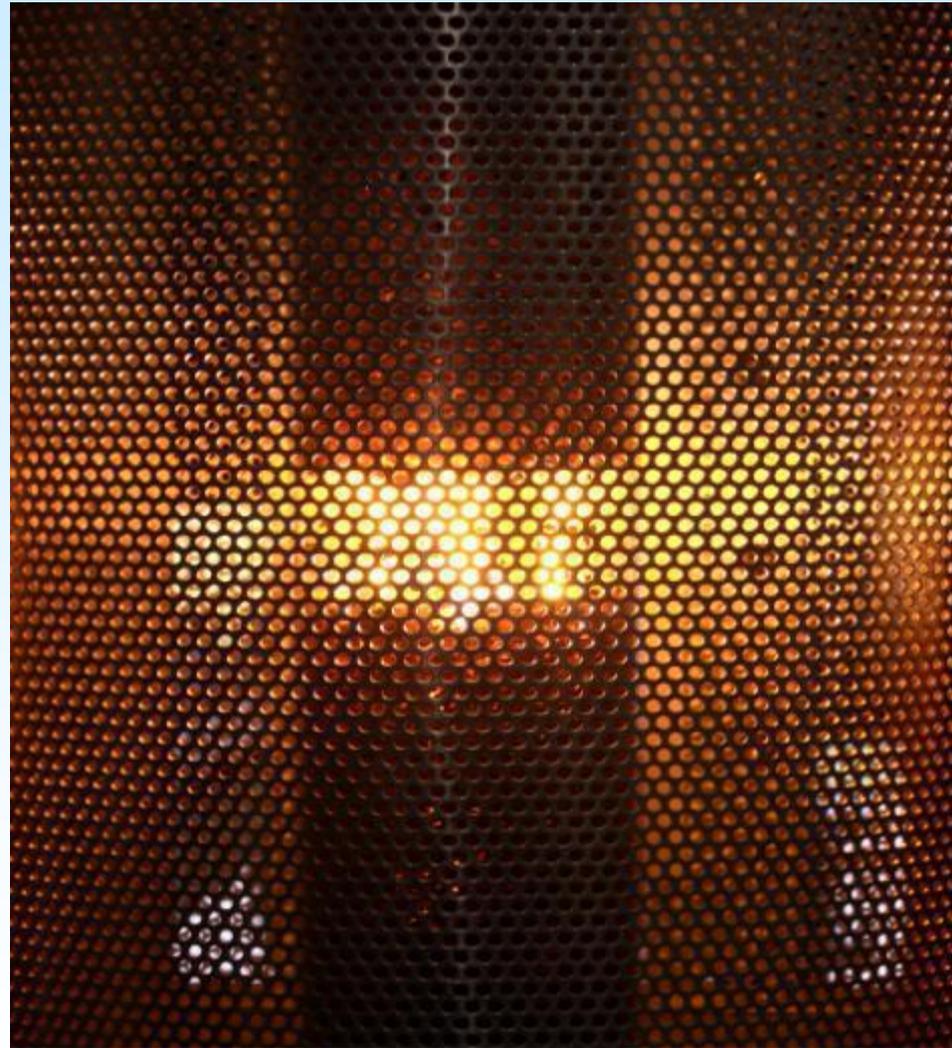
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# Reactor Tube Inside View



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# Test Results from Depressurization of 2,000-gallon Tank Containing N<sub>2</sub>O<sub>4</sub> Liquid in Nitrogen (F<sub>initial</sub> = 7.5-scfm)

Time (min)	Process Pressure (psig)	Tank Pressure (psig)	Reactor 1 Temp. (F)	Reactor 2 Temp. (F)	Reactor 3/4 Temp. (F)	Measured Outlet NOx Concentration (ppm)
0	1.8	34	81.4	80.9	85.4	0
10	2.64	31	138	153.7	163	0
20	2.42	28	142.2	151.5	175.5	0
30	2.23	25.5	139.4	140.7	176.9	0
40	2.07	23	125.8	136.2	175.1	0
50	1.87	20.5	124	134	171	0
64	1.67	18	121.3	130.5	164.8	0
70	1.59	16.5	120.6	127.1	161.8	0
80	1.45	15	119.1	126.1	157.8	0
90	1.32	13	118.2	123.8	152.1	0
100	1.21	11	116.6	121.5	146.8	0
110	1.09	9.5	115.7	120	152.2	0
120	0.97	8	114.3	117.9	137.1	0
130	0.89	6.5	113.3	118.4	136.9	0
140	0.78	5	112.1	116.2	135.8	0

140

Microwave Scrubber shut down normally



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# Field Testing Results

- Post-Installation Tests
  - August 2006
  - January 2007
- Start-Up Tests
  - January 2007



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## Microwave Leak Test, PEL = 8.17 mW/cm<sup>2</sup>

Location	Power Emission, mW/cm <sup>2</sup> , 17/08/06	Power Emission, mW/cm <sup>2</sup> , 30/01/07
50, 25, 12-ft from unit	0.00817-0.1634	Negligible
Right side of elec. cab.	.29412	Negligible
1-ft from top of Reactor #1	2.3693	Negligible
1-ft from top of Reactor #2	1.4706	0.32
1-ft from top of Reactor #3	8.13732	0.32
1-ft from top of Reactor #4	3.0229	1.69
2-ft from top of Reactor #4		0.51
Back of unit	0.4085	0.16



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# Noise Level Readings, dBA

Location	Readings on 17/08/06	Readings on 130/01/07
50 ft from unit front	65	
25 ft from unit front	68	70.7
12 ft from unit front	74	76.4
1 ft from unit front	79	80
Right side of Elc. Cab.	89	86.5
1-ft from cooling air bl.	96	93



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# System Pressure Test

Time, min	System Pressure, psig
0	14.4
1.5	14.35
5	14.27
8	14.24
12	14.17
15	14.14



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# PLC Emergency Shutdown Function Tests

- System Over Pressurization
  - The system was automatically shut down when the system pressure reached 10-psig
- High Temperature Alarm and Automatic Shut Down
  - Tested all five thermocouples triggered the high temperature alarm and shutting the system down



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# PLC Emergency Shutdown Function Tests

- Low Cabinet Purge Pressure
  - The system did not start when the electric cabinet was open
  - When the cabinet pressure was lower than 0.25-inch gauge, the automatic system shut down was initiated
- Cooling Water Flow Alarm
  - When the cooling water flow was interrupted, the automatic system shut down was initiated



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# PLC Emergency Shutdown Function Tests

- Microwave Generator Shut Down due to
  - No cooling water flow
  - Cooling water temperature greater 90 deg F
  - Reflected power greater than 30%



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# Pre-Startup Checklist

## Microwave Oxidizer Scrubber

1. Verify nitrogen isolation valve, ISV 1611, is open
2. Verify that the isolation valve, ISV-1611 before pressure relieve valve, PRV-1601 is open
3. Turn on main power breaker in UPC electric control room to power microwave scrubber.
4. Open oxidizer vapor isolation valve, ISV 1601.
5. Read carbon hopper levels READOUT on control panel (LI-1601 – 1604).
6. Fill carbon hoppers if level is less than 60%.
7. Verify that the LCD reads **READY**.
8. OPEN ISV-1612 (Microwave Scrubber outlet isolation valve)
9. Verify/OPEN BV-474B (MWS redundant outlet isolation valve)
10. OPEN BV-283B (MWS inlet isolation valve)
11. CLOSE BV-299 (LQ2X vent outlet valve)
12. OPEN BV-232 (Tank 203 flow valve)
13. OPEN BV-239A (Tank 203 redundant vent valve)
14. OPEN BV-239B (Tank 203 vent valve)



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# Startup and Normal Operating Procedure

1. Push the system startup button (CB-3001)
2. The PLC will automatically run a startup sequence. This sequence will take approximately 10 minutes to complete. At the end of the startup sequence, the PLC will automatically open PV-1601, initiating oxidizer flow to the unit.
3. The microwave scrubber will operate automatically.
4. If necessary, the system can be shut down immediately by pressing the **emergency shutdown button** (CB-3003).
5. If the microwave scrubber should operate out of range, the PLC will force the system into an emergency shutdown mode.
6. When operation is complete, the operator will shut down the microwave scrubber by pressing the **manual shutdown button** (CB-3002).
7. Check critical connections and valves for NO<sub>2</sub> leakage using the hand-held Interscan 4000 NO<sub>2</sub> detector.



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# Normal Shutdown Procedure

1. CLOSE BV-239A
2. CLOSE BV-239B
3. CLOSE BV-232
4. OPEN BV-299
5. CLOSE BV-283B
6. The system will run continuously until the **manual shutdown control button** (CB- 3002) is pressed.
7. When the shutdown button is pressed, the PLC will shut down all operations independently.
8. When shutdown is complete, turn off the main power breaker.
9. Once electrical power is shut off, close ISV-1601 to isolate the microwave scrubber from the oxidizer supply.
10. CLOSE BV-474B
11. Perform PWI-O-053, Sequence 19 (FACILITY SCRUBBER SHUTDOWN)



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# Restart After Fault Alarm

- When the problem that caused the fault alarm to activate has been identified and corrected, press the **fault reset button** (CB-3004)
- When “**System Ready**” is displayed on LCD, follow the **Startup and Normal Operation Procedure**



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## NTO Test on 01/02/07, inlet conc.=400,000 ppm

Time, min	NO <sub>x</sub> , ppm	NO, ppm
2	206	28
20	40	10
31	50	24
65	97	5
165	4	4



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# Monthly Maintenance

- Inspect reactor piping and all connections and fitting for any sign of leakage
- Inspect the air-cooled heat exchangers for signs of fouling or contamination on exterior surfaces
- Clean with compressed nitrogen if any sign of fouling is detected
- Conduct system leak test pressuring the system to 9-psig



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# Monthly Maintenance

- Check cooling water for signs of microbial activity (discoloring or odor)
- Add biocide to cooling water if microbial activity is evident
- Check microwave reactor connections for microwave leakage
- Check the system ground connections



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# 6-Month Maintenance

- Clean air-cooled heat exchanger surfaces with high pressure water spray to remove accumulated deposits
- Inspect and clean pump strainer in cooling water loop



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# Annual Maintenance

- Drain and flush the cooling water tank and system
- Refill the cooling water tank with clean water and treat with biocide



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# Microwave Scrubber for Fuel Vapor

- Construction of Microwave Fuel Scrubber began in September 2006 and was completed in May 2007
- Laboratory testing was conducted in May 1 - June 15, 2007
- Installation at VAFB began on June 25 and completed in the morning of June 29, 2007
- Post-installation tests were completed on June 29, 2007



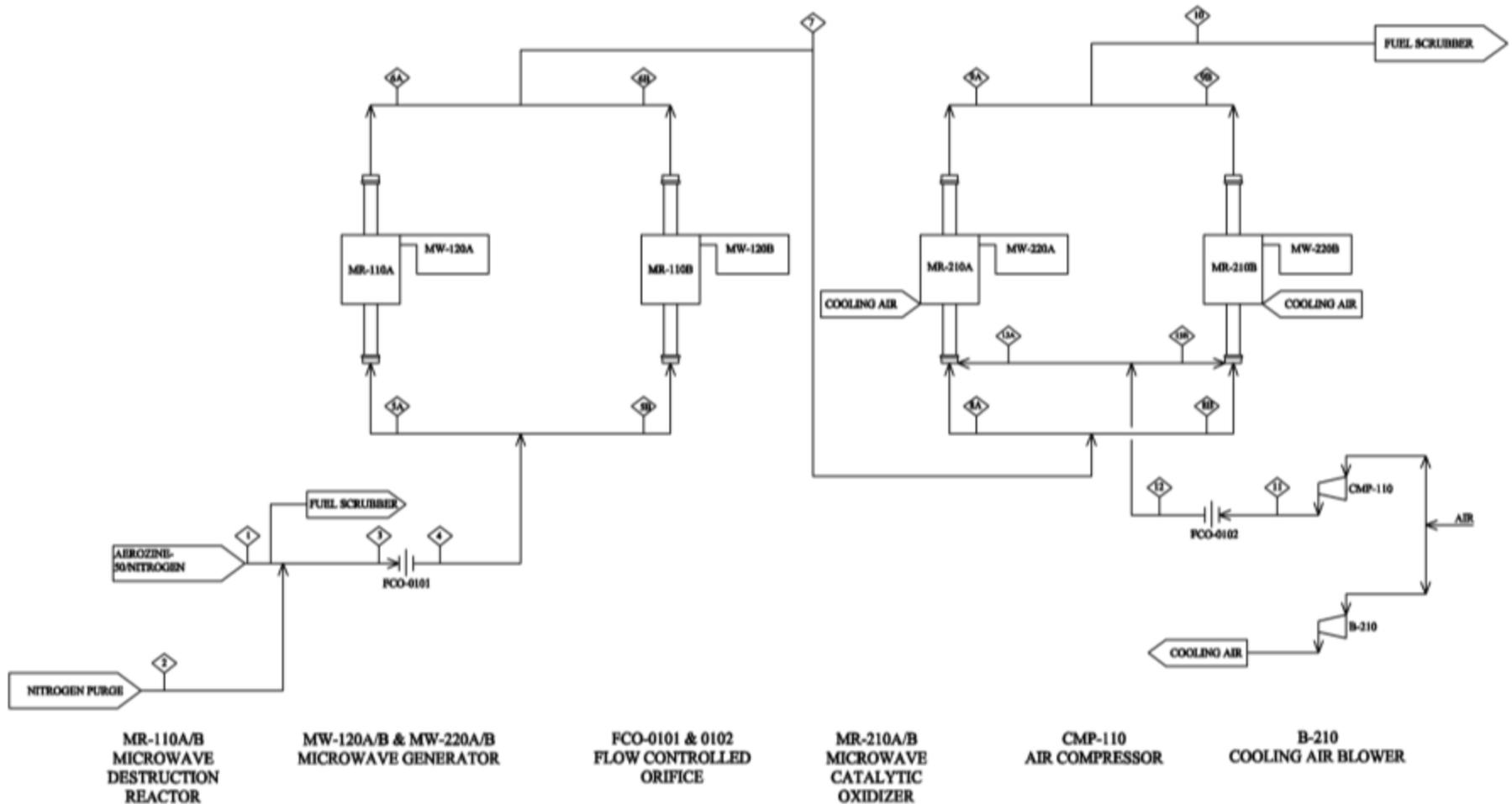
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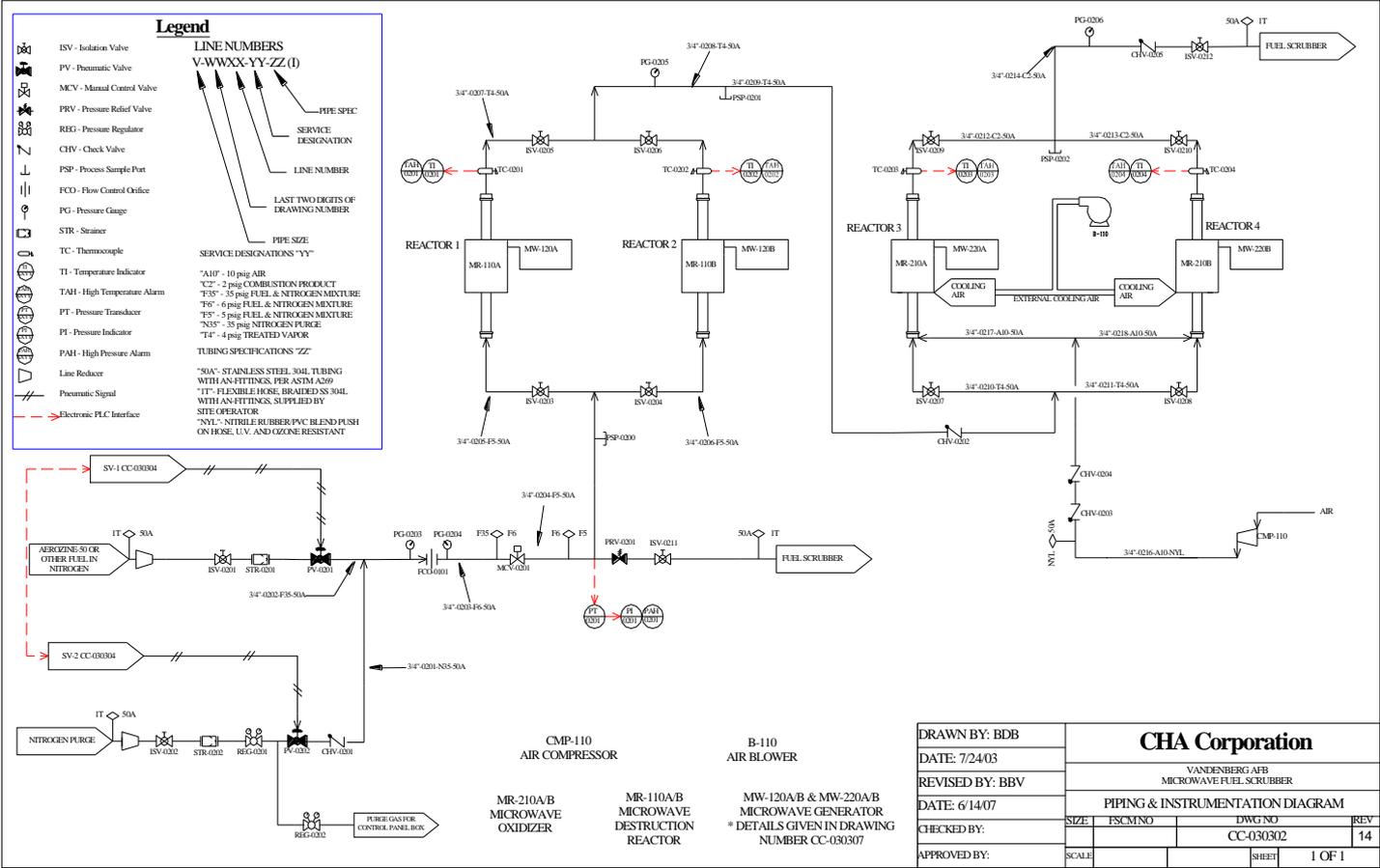
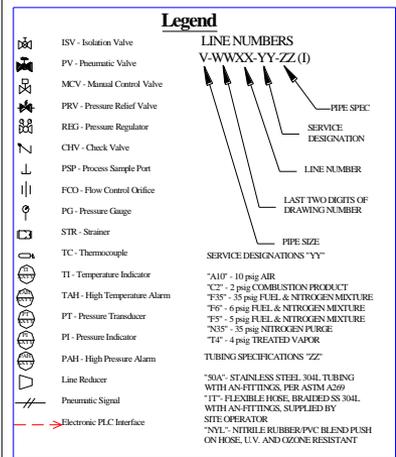


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# PFD for Microwave Fuel Scrubber





DRAWN BY: BDB		<b>CHA Corporation</b>	
DATE: 7/24/03			
REVISED BY: BBV		VANDENBERG AFB MICROWAVE FUEL SCRUBBER	
DATE: 6/14/07		PIPING & INSTRUMENTATION DIAGRAM	
CHECKED BY:	SIZE:	FSCM NO	DWG NO
			CC-030302
APPROVED BY:	SCALE:	SHEET	REV
			14
			1 OF 1



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# Microwave Fuel Scrubber



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# Laboratory Testing of Fuel Scrubber

- Microwave leak test
  - Microwave leaks from reactors were very small and below the PEL
- System Leak test
  - The system was pressurized to 13-psig
  - The system pressure decreased 0.5 psi for 15 minutes

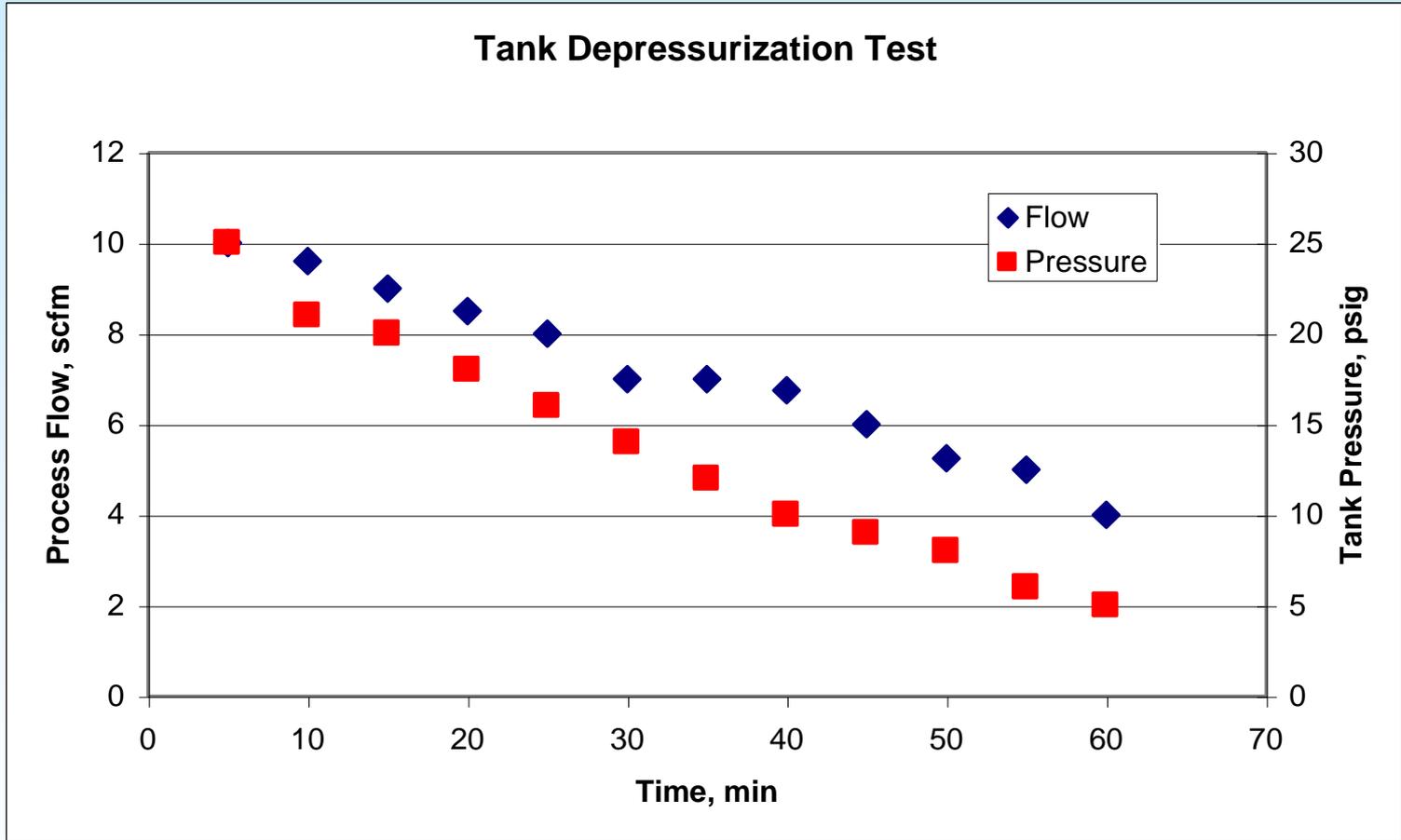


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# Hydrazine Test

Time, min	Hydrazine Conc. Of Inlet gas, ppm	Hydrazine Conc. of Outlet gas, ppm
10.0	26.0	0.0
15.0	26.0	0.0
20.0	24.0	0.0
25.0	24.0	0.0
30.0	28.0	0.0
35.0	33.0	0.0
40.0	33.0	0.0
45.0	33.0	0.0
50.0	34.0	0.0
55.0	35.0	0.0
60.0	36.0	0.0
65.0	37.0	0.0
70.0	36.0	0.0



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# MMH Test

Time, min	1st stage THC, ppm	2nd stage THC, ppm	MMH Conc. Of Inlet Gas, ppm	MMH Conc. of Outlet Gas, ppm
10	376.0	105.0	710.0	0.0
15	510.0	130.0	710.0	0.0
20	613.0	170.0	710.0	0.0
25	715.0	172.0	725.0	0.0
30	838.0	215.0	760.0	0.0
35	915.0	211.0	775.0	0.0
40	1150.0	245.0	790.0	0.0
45	1170.0	251.0	800.0	0.0
50	1360.0	285.0	800.0	0.0
55	1380.0	274.0	860.0	0.0
60	1570.0	311.0	910.0	0.0



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# Pre-Startup Checklist

- Verify OPEN GN2 inlet isolation valve located on the Microwave Scrubber (ISV 0202)
- Verify the isolation valve, ISV-0211, is open (after pressure relieve valve)
- Turn on main power breaker in UPC electric control box to power microwave scrubber.
- Verify that the cooling water pump and air compressor are operating
- Open fuel vapor isolation valve (ISV 0201).
- Verify that the LCD in PLC reads READY.
- OPEN BV-374B (Microwave Scrubber (MWS) outlet isolation valve)
- OPEN BV-183B (MWS inlet isolation valve)
- CLOSE BV-199 (LQ4X vent outlet valve)
- OPEN BV-142 (Tank 104 flow valve)
- OPEN BV-149A (Tank 104 redundant vent valve)
- OPEN BV-149B (Tank 104 vent valve)



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# Startup and Normal Operating Procedure

- Push the system startup button (CB-3001)
- The PLC will automatically run a startup sequence. This sequence will take approximately 10 minutes to complete. At the end of the startup sequence, the PLC will automatically open PV-0201, initiating fuel vapor flow to the unit.
- The microwave scrubber will operate automatically.
- If necessary, the system can be shut down immediately by pressing the **emergency shutdown button** (CB-3003).
- If the microwave scrubber should operate out of normal operating condition, the PLC will force the system into an emergency shutdown mode.
- When operation is complete, the operator will shut down the microwave scrubber by pressing the **manual shutdown button** (CB-3002).
- Check critical connections and valves for fuel vapor leakage using the hand-held Interscan 4000 hydrazine detector.



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# Normal Shutdown Procedure

- **Step 1:** CLOSE BV-149A
- **Step 2:** CLOSE BV-149B
- **Step 3:** CLOSE BV-142
- **Step 4:** OPEN BV-199
- **Step 5:** CLOSE BV-183B
- **Step 6:** The system will run continuously until the **manual shutdown control button** (CB-3002) is pressed.
- **Step 7:** When the shutdown button is pressed, the PLC will shut down all operations independently.
- **Step 8:** When shutdown is complete, turn off the main power breaker.
- **Step 9:** Once electrical power is shut off, close the fuel vapor isolation valve (ISV-0201) to isolate the microwave scrubber from the fuel supply.
- **Step 10:** CLOSE BV-374B
- **Step 11:** Perform PWI-20-O-054, Sequence 19 (SECURING FROM HAZARDOUS OPERATIONS)



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# Restart After Fault Alarm

- When the problem that caused the fault alarm to activate has been identified and corrected, press the **fault reset button** (CB-3004)
- When “**System Ready**” is displayed on LCD, follow the **Startup and Normal Operation Procedure**



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# Monthly Maintenance

- Inspect reactor piping and all connections and fitting for any sign of leakage
- Inspect the air-cooled heat exchangers for signs of fouling or contamination on exterior surfaces
- Clean with compressed nitrogen if any sign of fouling is detected
- Conduct system leak test pressuring the system to 9-psig



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# Monthly Maintenance

- Check cooling water for signs of microbial activity (discoloring or odor)
- Add biocide to cooling water if microbial activity is evident
- Check microwave reactor connections for microwave leakage
- Check the system ground connections



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# 6-Month Maintenance

- Clean air-cooled heat exchanger surfaces with high pressure water spray to remove accumulated deposits
- Inspect and clean pump strainer in cooling water loop



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# Annual Maintenance

- Drain and flush the cooling water tank and system
- Refill the cooling water tank with clean water and treat with biocide



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# Microwave Fuel Scrubber Field Test

Time, min	T1, °F	T2, °F	T3, °F	T4, °F	T cooling, °F	T cabinet, °F	P cabinet, in. H <sub>2</sub> O	P process, psig
1	69.1	69.8	150.1	161.1	66.9	83.7	0.13	2.85
5	74.1	78.0	151.2	152.0	67.5	80.1	1.22	3.74
10	90.0	101.5	169.2	176.5	68.3	81.7	1.19	3.76
15	101.1	110.5	186.8	199.0	68.6	82.8	1.20	3.86
20	106.6	116.8	199.0	213.4	68.9	83.3	1.20	3.87
25	111.0	121.4	207.3	223.0	69.1	84.2	1.15	3.87
30	113.5	123.1	210.9	226.8	69.1	84.7	1.16	3.84
35	115.2	124.2	211.5	228.2	69.4	85.3	1.17	3.85
40	116.1	126.0	212.5	230.2	69.8	86.0	1.15	3.85
45	114.3	125.1	209.7	226.8	69.6	86.2	1.11	3.84
50	115.3	124.3	208.8	226.6	69.6	86.2	1.09	3.83
55	115.3	123.4	207.7	225.9	69.8	86.4	1.12	3.83
60	113.5	122.1	204.6	223.0	69.6	86.2	1.11	3.82



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# Aerozine-50 Destruction Field Test

Time, min	Inlet Concentration, ppm	1st Stage Outlet Concentration, ppm	2nd Stage Outlet Concentration, ppm	Destruction %
1	1600	n/a	5	99.7
5	1800	n/a	9	99.5
10	1800	n/a	8	99.6
15	1200	n/a	12	99.0
20	1200	n/a	12	99.0
25	1200	n/a	13	98.9
30	1200	23	n/a	98.1
35	1200	6	n/a	99.5
40	1200	6	n/a	99.5
45	1200	2	n/a	99.8
50	1200	2	n/a	99.8
55	1200	2	n/a	99.8
60	1200	1	n/a	100.0



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# Avoid Verbal Orders

**TO:** ITBINC/Kurt Kessel

**DATE:** 12/17/2008

**FROM:** TA-B1C/NEPA Compliance

**SUBJECT** KSC Record of Environmental Consideration (REC)

**CHECKLIST #:** 7270

## 1. PROJECT INFORMATION

**Project Title:** Hypergolic Propellant Destruction Evaluation

**Project Lead:** Chuck Griffin, KT-A2, 867-6225

**Directorate Project No.:** DELIVERY ORDER  
#029

**EPB Reviewer:** LPH

**Facility No.:** LC 17 AND FSA 1

## 2. NEPA DETERMINATIONS

- a. **Categorical Exclusion per 14 CFR Part 1216.305(d)**
- b. **Environmental Assessment (EA) Required per KNPR 8500.1**
- c. **Environmental Impact Statement (EIS) Required per KNPR 8500.1**
- d. **Project on CCAFS:**

## 3. ENVIRONMENTAL REQUIREMENTS

- a. **Non-Permit Requirements**       **YES**                       **NO**
- b. **Permit Requirements**               **YES**                       **NO**

AF FORM 813: This project is located on CCAFS property. Coordination with the 45th CES/CEVP is required. AF Form 813 must be completed for project review by the Air Force. Contact Angy Chambers (853-6822, 45 CES/CEVP) if clarification is required.

3.a.1. **HAZARDOUS/NON-HAZARDOUS WASTE:** All hazardous and non-hazardous wastes generated on KSC must be managed, controlled and disposed of per the KSC Waste Management requirements outlined in KNPR 8500.1. A Process Waste Questionnaire (PWQ), KSC Form 26-551 along with any supporting documentation (MSDS, product formulation, lab analyses) must be submitted to the IHA Waste Management Office for each waste stream generated. That office will then generate a Technical Response Package (TRP) which will give direction on proper handling, storage, and disposal of the waste stream. Please contact IHA Waste Management Services at 867-8640 if assistance is required.

3.a.2. **RADIATION:** This project involves the generation of a radiation source (microwave) which must be evaluated by the Comprehensive Health Services (CHS) Health Physics Group. A KSC Radiation Use Form (KSC Form 16-451) must be completed and submitted to the NASA TA-B1A office. The source of the radiation will be evaluated for possible hazards and a use authorization or exemption will be issued. If you have any questions contact Rob Bullock, IHA-022, at 853-5609.

3.a.3. **AIR EMISSIONS:** Based on the information provided there are no air permitting requirements associated with the microwave destruction technology demonstration and the project may proceed as planned.

No other environmental issues were identified based upon the information provided in the KSC Checklist. This Record of Environmental Consideration (REC) does not relinquish the project lead from obtaining and complying with any other internal NASA permits or directives necessary to ensure all organizations potentially impacted by this project are notified and concur with the proposed project.

Due to potential changes in regulations, permit requirements and environmental conditions, statements in this REC are valid for 6 months, and subject to review after this period. It is the responsibility of the project lead to notify EPB if the scope of the project (including the design) has changed since the original checklist was submitted.

cc: C. Griffin/KT-A2  
K. Kessel/ITBINC  
H. Nguyen/TA-B1C  
A. Chambers/45 CES/CEVP

## Avoid Verbal Orders

**TO:** ITBINC/Kurt Kessel

**DATE:** 12/17/2008

**FROM:** TA-B1C/NEPA Compliance

**SUBJECT** KSC Record of Environmental Consideration (REC)

**CHECKLIST #:** 7270

- 4 Upon evaluation of the subject project, the above determinations have been made and identified. Contact the Environmental Program Office (TA-B1C) at 867-8448 for re-evaluation should there be any modifications to the scope of work.



12/17/2008 11:31:01 AM

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John Shaffer

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Date

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