

ChemE Car Safety Workshop Part 2

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Part 1 of the ChemE Car Training Program presented a brief history of the safety program, an introduction to the Engineering Documentation Package (EDP), and a partial discussion of the Job Safety Assessment (JSA) form.

Part 2 will complete the discussion of the Job Safety Assessment (JSA) Form, and will provide final details on the Engineering Documentation Package (EDP).

JSA – Page 5: Additional Hazard Detail

Fabrication & Operation Additional Hazard Detail Check List: List the major source(s) of the hazard and how it will be controlled. Check in an individual row, then the hazards sh

Hazard	Present During		
	Construction?	Operation?	
Pressure	☐	☐	
Toxicity	☐	☐	
Flammability	☐	☐	
Reactivity / Instability	☐	☐	
Hot Surfaces/ High Temp. > 150 F	☐	☐	

Please check hazards that are present and how they will be controlled.

JSA – Page 6: Chem. Quantities

Chemical Information Page

List the chemical name, state, concentration, and total quantity of chemical required for the competition.

Chemical Quantities: List below the chemical names, concentrati

Chemical Name	Chemical State Solid, Liquid, Gas	Concent Be sur

JSA – Page 6: Chem. Props.

Chemical Information Page

Chemical Properties and Hazards

Chemical Name	Physical State S, L, G	NFPA Ratings*			
		H	F	S	Sp.

Complete for **ALL** chemicals, including reactants, intermediates and products.

JSA – Page 6: Chem. Props.

Chemical Information Page

Incompatible Chemicals List chemicals present within the laboratory, and any others that may come in contact.	Flash Point Temp.	Flammability Limits	
		LFL	UFL

JSA – Page 7: Toxicology

Chemical Information Page

Chemical Toxicology, Regulation and Disposal: List the same chemicals that appear above, in the same order.

Chemical Name	Toxicology		
	TWA	PEL	Other

TWA: Threshold Limit Value, Time weighted average

PEL: Permissible exposure limit (OSHA)

These can usually be found on the MSDS.

JSA – Page 7: Toxicology

The **Threshold Limit Value (TLV)** is the maximum exposure limit to humans for 8 hours a day, 40 hours per week, that does not cause any noticeable effect.

The **TWA** is the time weighted average.

The TLVs are promulgated by the American Conference of Governmental Industrial Hygienists (ACGIH), a professional society.

The **Permissible Exposure Limit (PEL)** is the same thing, but is promulgated by OSHA, a government organization.

JSA – Page 7: Toxicology

Chemical Information Page

List the same chemicals that appear above, in the same order.

Hazardous Waste Number	OSHA Regulated?	Personal Protective Equipment Specific to this Chemical

JSA – Page 7: Chem. Rx.

Chemical Reactions: Provide details on any chemical reaction(s) that occur on your car. Please show the species involved, the stoichiometry and the heat of reaction, if available. Also list side reactions and any other reactions that may impact safety.

JSA – Page 7: Biohazards

Biohazards: Provide additional detail on the biohazards involved. List the name of the organism used, the biohazard level for this organism, and a description of how these organisms will be handled safely.

JSA – Page 8: Safe Operations

Sequence of Steps
Emergency Shutdown
Start-up Procedure
Run Time Procedure
Shutdown Procedure
Cleanup / Waste Disposal

JSA – Page 8: Safe Operations

Emergency Shutdown:

List a few things you can do prior to evacuating the laboratory.

Start-Up Procedure:

List the steps to get ready to operate your vehicle.

Run Time Procedure:

Steps required to operate the vehicle.

JSA – Page 8: Safe Operations

Shut-down Procedure:

Steps required to normally stop the vehicle and return it to a safe state.

Clean-up / Waste Disposal:

Steps required to clean the equipment and dispose of all chemical wastes.

JSA – Page 8

Potential Hazards	Procedure to Control	PPE
Potential Hazards	Procedure to Control Hazard	PPE or Equipment Required

JSA Application

The JSA is best applied during the conceptual design and construction of the vehicle. It is very useful for identifying the hazards in your design and developing methods to control those hazards.

Job Safety Assessment Form
Chem-E-Car
2009 National Competition - Updated August 2009

University:	Vehicle Name:
JSA Author Contact Name:	Author Email:
Faculty Supervisor:	Supervisor Email:
Revision #:	Revision Date:

Engineering Documentation Package (EDP)

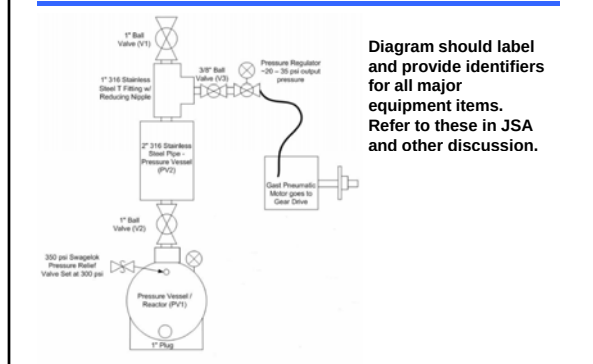
1. Job Safety Analysis (JSA)
2. Flow diagram of car
3. Design basis for maximum operating pressure
4. Design basis for estimating relieving mass flow rate
5. Equipment specifications summary table and equipment specification data
6. Pressure certification of vessel
7. Standard operating procedures
8. Test Data
9. Car experimentation area floor plan
10. Management system for vehicle modifications
11. Management system for chemical use and disposal
12. Pictures of vehicle, as it would appear on starting line
13. Material Safety Data Sheets (MSDS)

Engineering Documentation Package (EDP)

An example engineering documentation package is available on the AIChE ChemE car web site.

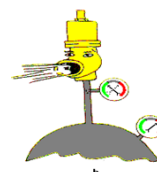
Please consult for details.

Flow Diagram of Car



Design Basis for Maximum Operating Pressure

Use reaction stoichiometry, vessel volumes, equipment consumption specifications, etc., to calculate maximum pressure required to drive your car the maximum distance (100 ft) with the maximum weight (500 ml).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Calculation of ChemE Car Vehicle Pressures															
2	Note: This calculation assumes stoichiometric reaction.															
3																
4	Volume of vehicle vessel:			3.08 liters												
5																
6	Properties of chemicals:															
7	Specific gravity of liquid glacial acetic acid:				1.05											
8																
9	Molecular weights:				gm/gm-mole											
10	Glacial acetic acid:				60.05											
11	Sodium bicarbonate:				84.01											
12	Sodium Acetate:				136.08											
13	Carbon dioxide:				44											
14	Water:				18											
15																
16	Note: Need to subtract water product volume from chamber volume in doing pressure calculation.															
17																
18	**** Glacial Acetic Acid ***** Sodium Bicarbonate ** Water Produced *** Carbon Dioxide **** Pressure ***** Gas Volume at 1 atm, 60 F															
19	(mol)	gm	gm-moles	gm-moles	gm	gm-moles	gm	gm-moles	liters	atm	psi	atm	psi			
20	10,000	10,500	0.175	0.175	14,690	0.175	3,147	0.175	1,077	1.390	20,428	0.146289				
21	10,000	10,500	0.175	0.175	14,690	0.175	3,147	0.175	1,077	1.390	20,428	0.146289				
22	20,000	21,000	0.350	0.350	29,379	0.350	6,295	0.350	2,154	2.782	40,856	0.292578				
23	30,000	31,500	0.525	0.525	44,069	0.525	9,442	0.525	3,231	4.173	61,411	0.438867				
24	40,000	42,000	0.699	0.699	58,758	0.699	12,590	0.699	4,307	5.576	81,365	0.585076				
25	50,000	52,500	0.874	0.874	73,448	0.874	15,737	0.874	5,664	6.977	102,342	0.731345				

Design Basis for Estimating Relieving Mass Flow Rate

The relief device protects your vehicle from high pressure by relieving mass from your ChemE car process.

Your required relief device is only capable of expelling material at a fixed max. rate. This information is available from the vendor's equipment specifications.

The relief device must be capable of discharging mass as fast as it is being produced by your chemical reaction.

However, information on the reaction rate is not usually available unless extensive experiments are done.

Thus, your only approach is to prevent excessive pressures by stoichiometric control. Must convince reviewers that you have achieved this.

Equipment Specifications Summary Table / Data

Provide a summary table listing each major piece of equipment. Include valves, tubing, pipes, vessels, regulators, turbines, etc. List important specs, such as temperature and pressure, material of construction, etc.

Provide copies of the vendor's equipment specification sheets for all equipment.

Equipment Specifications Summary Table

Equipment Item	Vendor / Model	Material of Construction	Critical Design Specifications
Vessel Sheet Metal	MacSteel	Stainless 316/104	Max. Temperature: 925°F Tensile strength: 600 MPa
Relief Device - Spring operated	Swagelok R3A	Stainless	Set pressure: 500 psi 12 SCFM discharge rate at set pressure
Regulator	Granger R314-S	Stainless	Temperature range: 0°C to 65°C Supply pressure max: 21 bar Set to 30 psi output pressure
Stainless steel ball valve - 1/2 inch	Golden Highope Jlandet C-HA-2P	Stainless	Pressure rating: 1500 psi at 100°F
Stainless steel pipe - 3/4 inch	Cetaco	Stainless	Max. pressure: 80 psi This will operate at 20 psi with an rpm of 1000 and 1 SCFM gas flow
Gas air motor	Quest model M1.62	Aluminum	Max. pressure: 80 psi This will operate at 20 psi with an rpm of 1000 and 1 SCFM gas flow
Manufactured pressure vessel	Manufactured	Stainless 316/104	Set to 500 psi with no measurable deformation of vessel. See pressure certification.

Pressure Certification of Vessel(s)



See Appendix A in the Safety Rules and also the example Engineering Documentation package.

A new vessel can be certified by the original vendor, but if over 5 years old, or damaged or corroded, it must be recertified. This can be done by your team, or by an outside vendor.

Standard Operating Procedures (SOPs)

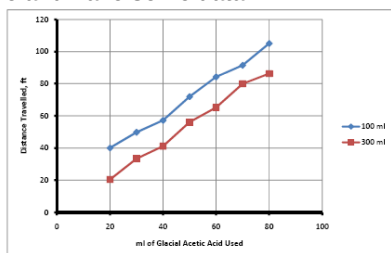
These can be developed directly from the Safe Operating Procedures Page of the JSA. Include only the steps, not the hazards and controls.

Start-up Procedure

1. Don PPE, including safety glasses and gloves.
2. Place beaker on spill tray.
3. Weigh out the designated mass of sodium bicarbonate in a beaker using the scale.
4. Place graduated cylinder on spill tray.
5. Measure designated volume of glacial acetic acid using a graduated cylinder. Leave in graduated cylinder.
6. Measure out in graduated cylinder required water based on sodium bicarbonate solubility. Add 20% extra to insure all dissolved.
7. Open 1" plug in pressure vessel.
8. Carefully pour sodium bicarbonate powder thru hole.
9. Close 1" hole in PV1 with 1" plug. Tighten fully.
10. Close valve V3 to insure that liquid does not enter regulator.

Test Data

Need some indication that you have run the vehicle and have some data.



Car Experimentation Area Floor Plan



Provide a layout of the area you will be testing your vehicle at your home institution. Show location of safety equipment:

- Fire extinguisher
- Safety shower / eyewash
- Spill kit
- Fire alarm
- First aid kit

Management System for Vehicle Modifications

This section applies to changes done after your engineering documentation package as been reviewed. The purpose of this is to inform the inspectors of the changes that have been made since the EDP was reviewed and to insure that any new hazards have been identified and addressed.

See the example EDP.

Management System for Chemical Use and Disposal

This applies to chemical storage, use and disposal at your home institution and also the competition.

See example Engineering Documentation Package.



Pictures of Vehicle



The picture must show exactly how the vehicle will look at the starting line of the competition.

Material Safety Data Sheets

Provide vendor supplied MSD sheets for all reactants, products and intermediate chemicals. Include any solvents or other utility chemicals that are used.



PRODUCT NAME: CARBON DIOXIDE, GAS

1. Chemical Product and Company Identification

BOC Gases,
Division of
The BOC Group, Inc.
875 Mountain Avenue
Murray Hill, NJ 07974

BOC Gases
Division of
BOC Canada Limited
5975 Falbourn Street, Unit 2
Mississauga, Ontario L5R 3W6

Summary of Workshop

You need to identify the hazards on your ChemE car, control or eliminate these hazards, and then convince the EDP reviewers and the inspectors that this has been done successfully.

You also need to follow the management procedures outlined in the rules: JSA preparation, EDP submission, and car inspection.

ChemE Car Qualification Test

Now that you have viewed the Chem-E-Car Safety Training presentation, please access www.aiche.org/chemecartest to take the required qualification test.

Simply watching the video WILL NOT qualify you to compete. As of January 2010, each team member of a NEW Chem-E-Car team or a team that was not qualified to compete at past competitions MUST pass the test to compete at a Chem-E-Car competition.

ChemE Car Qualification Test

Once you pass the test with an 80% or higher score, your name will be added to the list of qualifiers maintained at AIChE headquarters.

If you fail the test, you will be given another opportunity to pass.

Please write down this website, as it is not on the public AIChE student website - www.aiche.org/chemecartest. This is where you will go to access the test and receive more details.

Good luck for your competition!

Have a safe experience!

