Operating practices

This condensed survey contains highlights obtained from 63 Air and Ammonia Plant operators and designers. Answers were received from about 60% of the U.S. operators.

The detailed 38-page survey was prepared by a subcommittee with Cooled, N_2 blanketed the following members: Peter S. Hepp, Chm., Sun Oil Co.; Norton Walton, SunOlin Chemical (previously with Atlantic Refining); R. F. Bollen, Dow Chemical of Canada; R. W. Rotzler, Monsanto Chemical. The listing includes numbers in parentheses after each statement. These refer to the total number of actual answers, but do not include those who had no reply to the specific question.

and dumped into		
closed container Cooled, N_2 blanketed, and dumped into	2	7 %.
water	3	11 %
	28	100 %
Deoxo Catalyst:		
Purge with N ₂ Submerge in water	3	75 % 25 %
•	4	100 %
Shift Catalyst:		
Slow, controlled oxidation Cool with steam	14	73%
inert gas	3	16%
flood with water or	2	11%
	19	100 %
Reforming Catalyst:		
Slow controlled oxi-		2 0 0
Cool and dump	8	73% 27%
r.		100 %
Methanator Catalyst:		
Oxidize	1	
Other:		
Oxidize all catalyst before removal	8	
 B. 22% protect nickel the formation of nicke steam purging, 26% b 17% purge by steam for and 17% use CO free g C. 79% purge the air equipment before intr (48) 79% use N₂ for purge. D. 92% will not use main ing instruments on NH 	catalys $1 carbo y N2 p llowed as. (23) \cdot out croducing(38)ercury cr_3 system$	t from myl by burging, by air, of NH ₃ . g NH ₃ .
Air Plants, Inlet Air:	÷	
A. 63% monitor for imp	ourities.	(40)

B. Of those who monitor 80% monitor after the compressors. (25) 28% monitor for impurities continuously, and 52% monitor intermittently. (25) 88%

Ammonia Loading:

A. 57% use hose for ammonia loading and 21% use both hose and pipe with swivel joints. (48)

B. 60% use stainless steel braided or reinforced hose, and 40% use rubber hose. (47)

C. 49% test at an average of 5 months. (45)

Of those who used rubber hose, 67% tested hydrostatically at regular intervals. Of those who used stainless steel reinforced hose, 60% did not hydrostatically test at regular intervals.

D. 79% of those who test hydrostatically tested at an average of 350 lb./ sq. in. (29)

E. 26% discarded hose at an average of 11 months. (46) The remainder had no set schedule.

F. 40% did not ground cars and trucks when loading, and 58% did. (48)

Hydrostatic Testing:

A. 52% hydrostatically test sub-zero equipment. (46) 33% of the 52% test this equipment at an average of 5 years. $(2\overline{4})$

B. 56% hydrostatically test syn loop vessels. (43) 50% of the 56% test the vessels at an average of 5 years. (24) C. 63% hydrostatically tested compressor suction and discharge bottles and interstage separators. (51) 29% tested at an average of 5 years. (31) D. 54% hydrostatically tested other vessels such as caustic towers, driers, etc. (52) 37% of the 54% tested at an average of 5 years. (27)

E. 53% test pneumatically. (53) 67% of the 53% test at an average of 110% of design. (27) 22% tested with air, 41% with N₂, and 26% with both. (27)

Temperature Limits for Carbon Steel:

A. 84% normally subject carbon steel

to an average temperature of -6° F. (53)

B. 56% have no specifications for carbon steel in low temperature service, and 28% use one of the following specifications: aluminum or silicon killed ASTM-A-300 C1.1 ASTM-Sec. 8, ASTM-A106B, A-212 or A-201. (50) C. 75% of the companies queried take precautions to protect piping leaving the cold box which, during upsets, may be subjected to abnormally low temperatures. Of those, 41% use copper or stainless piping as precautionary measures, and 17% have low temperature alarms or cut offs. (36)

Compressors:

A. 64% have tail rods; (56) of those, 42% use tail rod catchers. (48) B. Company response indicating specifications for purchasing and periodically testing compressor piston rods, (53)

Specifications	Number of Companies	Per cent
Mfg's. specs.	13	24
Magnaflux	9	17
X-ray or radiograph	3	6
Ultrasonic inspection	n 5	9
Die check or whitev	vash 5	9
Straightness	2	4
Specify hardness of	new	
rods	3	6
Use SAE 4140 steel	2	4
Miscellaneous	3	6

Miscellaneous:

A. How do you prepare spent catalyst for safe removal?

Catalyst:		
Purge with N ₂	8	29 %
Controlled oxidation	13	46 %
Cool and dump	2	7%

monitor for hydrocarbons, 28% monitor for oxides of nitrogen, and 44% monitor for C_2H_2 . (40)

C. 13% have more than one inlet, depending on wind direction. (38)

D. 7% employ catalyst beds to oxidize hydrocarbons in the inlet air. (40)

E. 87% used reciprocating air compressors, 38% discharged at 50 to 350 lb./sq. in., 33% at 350 to 700 lb./sq. in. and 27% at 2500 to 3000 lb./sq. in. (40)

F. 3% use non-lubricated rings as a lubricant in air compressors, 63% use hydrocarbon oils, and 34% use synthetic lubricants. (38)

G. The average maximum discharge temperature permitted on feed air compressors is 315°F. The committee found no apparent correlation between discharge pressure or oil type to the maximum temperature permitted.

Silica Gel Hydrocarbon Adsorbers in Air Plants:

A. 93% have silica gel filters in low pressure tower feed, 15% feed air to expanders, and 17% have the filters in the low pressure tower reboiler circuit. (53)

B. The average space velocities for filters in the low pressure tower feed is 47 lb. of air/lb. of gel/hr.

C. The average time between regenerations of low pressure tower feed filters is 136 hours. (35) 61% regenerate with N_2 , and 37% regenerate with air. (41)

D. During regeneration, feed filters are heated to an average temperature of $195^{\circ}F$.

E. The average time used to hold the gel at the average temperature is 6 hours. (37)

F. 54% discarded gel at an average of 22 months. (37)

G. Companies' criteria for discarding gel (47)

Criteria	Number of companies	Per cent
Color	18	53
Efficiency of		
adsorption	8	23
Oil contamination	4	12
Dusting; high pres- sure drop	. 8	23
At a set time: at	0	
shutdown	4	12

Air Plant Reboiler Monitoring:

A. 40% of the air plants remove the product O_2 as a vapor. Of these, 41% use auxiliary vaporizers. 81% of the vapor plants withdraw a liquid blowdown amounting to an average of 2% of the feed air.

B. 47% remove the product O_2 as a

liquid. 16% of these use auxiliary vaporizers.

C. 18% continuously analyze for total hydrocarbons, oxidized to CO_2 , on product O_2 or reboiler or vaporizer. 40% analyze continuously for product purities, O_2 in N_2 and/or N_2 in O_2 . (23)

D. Acetylene testing.

1. 90% analyze intermittently for C_2H_2 .

2. 90% test on a regular schedule, and 75% test every day, or more frequently. (37)

3. 75% of the tests are located in the reboiler or O₂ product, 17% in the vaporizer, and 17% in the absorber. (39)

4. 55% use Ilosvay for testing, 11% use Colorimetric, 8% use chromatographs. (31)

E. Hydrocarbon testing.

1. 57% intermittently test for hydrocarbons. (23)

Vol. III—Safety in Operating Air & Ammonia Plants—

Available soon Order now

Contents—

- 1. Complete reprint of material presented in this issue.
- Unpublished discussion covering 74 manuscript pages from the Tulsa Symposium.

To order Vol. III, or the earlier two volumes, write to:

A.I.Ch.E. 25 West 45th Street New York 36, N. Y.

2. 52% test every two days or more often.

3. 56% of the tests are in the reboiler or O_2 product, 35% are in the vaporizer or separator, and 22% are in the absorber. (26)

4. 13% use a chromatograph for the tests, 22% use infra-red, 16% use flame ionization, and 27% use miscellaneous methods. (18)

F. Nitrogen oxide testing.

1. 20% test intermittently for nitrogen oxides. (8)

G. Limits for Shutting Down. 1. 80% have definite shutdown limits in reboilers for C_2H_2 . (37)

a. The average shutdown limit for C_2H_2 in reboilers and vaporizers is 1.4 ppm. (33)

2. 32% have definite shutdown limits in reboilers for hydrocarbons. (37) a. The average shutdown limit for hydrocarbon in reboilers is 290 ppm. (14)

290 ppm. (14) 3. 12% have definite shutdown limits in reboilers for nitrogen oxides. (37)

a. The average reboiler shutdown limit for oxides of nitrogen is 0.1 ppm. (37)

4. 0.09 ppm is the normal level of C_2H_2 contaminants in reboiler. (30) 43 ppm is the average hydrocarbon contamination in reboiler. (21)

5. 65% of air plant operators hold liquid an average of 19 hr. in the air plant during an emergency shutdown. (38) 12% as long as contaminants do not exceed maximum limits.

Air Box Insulation:

A. 73% use mineral wool or rock wool insulation in the air plant. (29)

B. 55% specified an average of 0.15% oil maximum for air box insulations for safety reasons. (40)

Defrost and Solvent Wash of Air and H_2 Boxes:

A. For safety reasons, 75% defrost air boxes at an average of 12 months. (36)

B. 50% solvent wash the air box at an average of 2 years. (34) Trichloroethylene and carbon tetrachloride are the most frequently used solvents.

Handling Compressed Oxygen:

A. What type of compressor do	you
use to handle oxygen? (20)	•
Liquid pumps	45%
Centrifugal	15%
Piston compressors	60%
B. What materials of construct	tion
are used for piping? (18)	
Stainless steel	39%
Copper	33%
Carbon steel	17%
Aluminum	07 I L
Carbon with stainlass staal soo	0.0
tion	ററമ
Ev Hy Rod huses	2270 0007
C What the line line line line line line line lin	20%
C. What type values do you t	iser
(16)	~~
Non-ferrous	9%
Stainless	17%
Metal seated brass globe	17%
Miscellaneous	39%
D. What type of filters do you h	ave
ahead of the compressor? (15)	
Wire screen	30%
None	20%
Miscellaneous	25%
	- 214

Hydrogen Box Purging:

A. What is the approximate volume of your H_2 box?

B. How much N_2 purge do you use during normal operation?

Vol- UME TURNER, CU. FT. TURNERS NOTED HR. 1000 to 1000 1100 1100 1000 120 17.0 2750 0 0 0 3450 600 6 3500 No answer 3200 0 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 6 in. H ₂ O press. 5700 No answer 5700 1900 3.5 8000 2000 4 12,000 15,000 3.8 17,600 24,000 0.7 24,000 3.7 25,000 8400 4 No ans. A No ans. Average of 523 -1 (excluding 57) 4 C. 53% test the atmosphere in the hydrogen box for O ₂ an average of once every week. D. What limits are placed on these materials? No fixed limits 24% No insect of feed gas and the answer explosive 1 limit <th></th> <th></th> <th>•</th>			•
UME PURCE, CU. FT./HR. OVER, CU. FT. UNLESS NOTED HR. 1000 to 1900 210 2000 120 17.0 2750 0 0 3450 600 6 3500 No answer 3200 4 to 6 4000 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 6 in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 3.8 17,600 24,000 3 7,600 8400 4 No ans. Average of 523 1 -1 (excluding 57) 4 C. 53% test the atmosphere in the hydrogen box for O ₂ an average of once every week. D. D. What limits are placed on these materials? No fixed limits 24% No fixed li	Vol-	. .	TURN-
1000 to 1000 100 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 120 1000 155 1000 1500 1000 1.5 5240 1/16 in. H ₂ O press. 5700 No answer 12,000 15,000 12,000 15,000 12,000 15,000 12,000 12,000 12,000 420 12,000 420 12,000 420 12,000 420 12,000 420 12,000 420 12,000 420 12,000 420 12,000 420	UME CULET	PURGE, CU. FT./HR.	OVER,
to 1900 210 1900 120 17.0 2000 120 17.0 2750 0 0 3450 600 6 3500 No answer 3200 to 6 6400 210 4000 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 No answer 6200 ½ in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,600 24,000 0.7 24,000 40 7 24,000 40 7 35,000 8400 4 No ans. Average of 52% -1 -1 (excluding 57) 4 C. 53% test the atmosphere in the hydrogen box for O ₂ an average of once every week. D. What limits are placed on these materials?	1000		
1900 210 2000 120 17.0 2000 120 0 3450 600 6 3500 No answer 3200 to 6 6400 210 4000 1500 2.7 4500 3000 1.5 5700 6 in. H ₂ O press. 5700 No answer 6200 X in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 4 No ans. Average of 52% -1 (excluding 57) 4 C. 53% test the atmosphere in the hydrogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an average of once every week. (21) 62% test on a routine basis for flammable materials an average of once every	to		
2000 120 17.0 2750 0 0 3450 600 6 3500 No answer 3200 to 6 6400 210 4000 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 No answer 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,600 24,000 4 No ans. Average of 52%	1900	210	
2130 0 6 3500 No answer 3200 3200 3200 5240 1/16 in. H_2O press. 5700 6 in. H_2O press. 5700 No answer 6200 % in. H_2O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52% -1 -1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an average of once age of once every week. D. What limits are placed on these materials? No No No fixed limits 24% No 2,2%; 4%; 5%; 5%	2000	120	17.0
3500 No answer 3200 to 6400 210 6400 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 6 in. H ₂ O press. 6700 No answer 6200 % in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52%	3450	600	6
3200 to 6400 210 6400 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 6 in. H ₂ O press. 6200 % in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,600 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52%	3500	No answer	
to 6400 210 6400 1500 2.7 4500 3000 1.5 5240 1/16 in. H ₂ O press. 5700 6 in. H ₂ O press. 5700 No answer 6200 ¥ in. H ₂ O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 74,000 400 0.7 24,000 4 No ans. Average of 52% -1 (excluding 57) 4 C. 53% test the atmosphere in the hydrogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an average of once every week. D. What limits are placed on these materials? No fixed limits 24% No.fixed limits 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer <t< td=""><td>3200</td><td></td><td>ŀ</td></t<>	3200		ŀ
640015002.7450030001.552401/16 in. H20 press57006 in. H20 press5700No answer6200¥ in. H20 press670019003.580002000412,00015,0000.816,45050003.317,4006000317,60024,0000.724,0004205735,00084004No ans.Average of 52%-1-1(excluding 57)4C. 53% test the atmosphere in the hydrogen box for O2 an average of onceevery week.D. What limits are placed on thesematerials an average of once every week.D. What limits24%No fixed limits24%No-10 ppm5%O2-0%; 2%; 4%; 5%; 5%29%No answer24%(Some gave more than one limit)120%Note:29% set a maximum O2 content of 3% average.E. Will you make any repairs in the hydrogen box while running? (20)No67%No welding14%Limited repair5%Yes9%F. When shutdown, will you do hot work in H2 box without emptying insulation (in a cavity)? (20)Yes43%No52%Note: There was no apparent correlation between the source of feed gas and the answers to question E and F.G. What type of insulation do you have in H2 box? (21)Rockwool or Mineral wool	to 6400	910	
4500 3000 1.5 5240 1/16 in. H_2O press 5700 6 in. H_2O press 5700 No answer 6200 X in. H_2O press 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52%	4000	1500	2.7
5240 1/16 in. H_2O press 5700 6 in. H_2O press 5700 No answer 6200 X in. H_2O press 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52%	4500	3000	1.5
5700 No answer 6200 X in. H ₂ O press	5240	$1/16$ in. H_2O press.	••
6200 ¥ in. H_2O press. 6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52% - -1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	5700	No answer	
6700 1900 3.5 8000 2000 4 12,000 15,000 0.8 16,450 5000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52% - -1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	6200	¼ in. H ₂ O press.	
80002000412,00015,0000.816,45050003.317,4006000317,60024,0000.724,0004205735,00084004No ans.Average of 52%-1-1(excluding 57)4C. 53% test the atmosphere in the hydrogen box for O2 an average of onceevery week. (21) 62% test on a routinebasis for flammable materials an average of once every week.D. What limits are placed on thesematerials?No fixed limits24%Non-explosive24%H2 1%; 4%; lower explosive14%CO-10 ppm5%O2-0%; 2%; 4%; 5%; 5%29%No answer24%(Some gave more than one limit)120%Note: 29% set a maximum O2 content of 3% average.67%E. Will you make any repairs in the hydrogen box while running? (20)No67%No welding14%Limited repair5%Yes9%F. When shutdown, will you do hot work in H2 box without emptying insulation (in a cavity)? (20)Yes43%No52%Note: There was no apparent correlation between the source of feed gas and the answers to question E and F.G. What type of insulation do you have in H2 box? (21)Rockwool or Mineral wool81%H. Do you purge the air out of proceess equipment before introducing flammable materials? (21)Yes100%I. Purging process equipment: What do you use for purge? (21)N2	6700	1900	3.5
16,450 5,000 3.3 17,400 6000 3 17,600 24,000 0.7 24,000 420 57 35,000 8400 4 No ans. Average of 52% - -1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O_2 an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	8000	2000	4 0.8
17,4006000317,60024,0000.724,0004205735,00084004No ans.Average of 52%	16,450	5000	3.3
17,60024,0000.724,0004205735,00084004No ans.Average of 52%	17,400	6000	8
24,000 420 4 35,000 8400 4 No ans. Average of 52% 4 C. 53% test the atmosphere in the hy- drogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	17,600	24,000	0.7
No ans. Average of 52% -1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O ₂ an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	24,000	420	4
-1 (excluding 57) 4 C. 53% test the atmosphere in the hy- drogen box for O_2 an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	No ans.	Average of 52%	
C. 53% test the atmosphere in the hydrogen box for O_2 an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	-1	(excluding 57)	4
drogen box for O_2 an average of once every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	C. 53%	test the atmosphere in	the hy-
every week. (21) 62% test on a routine basis for flammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	drogen	box for O_2 an average	of once
basis for hammable materials an aver- age of once every week. D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	every w	/eek. (21) 62% test on a	routine
D. What limits are placed on these materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive 1 limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	basis fo	r nammable materials	an aver-
materials? No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	D. Wh	at limits are placed of	on these
No fixed limits 24% Non-explosive 24% H ₂ 1%; 4%; lower explosive limit 14% CO-10 ppm 5% O ₂ -0%; 2%; 4%; 5%; 5% 29% No answer(Some gave more than one limit) 120% Note: 29% set a maximum O ₂ content of 3% average. 67% No exerage.E. Will you make any repairs in the hydrogen box while running? (20) No 67% S% 67% No welding 14% Limited repairYes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% NoNo 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) YesYes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	materia	ls?	
Non-explosive 24% H_2 1%; 4%; lower explosivelimit14%CO-10 ppm5% O_2 -0%; 2%; 4%; 5%; 5%29%No answer24%(Some gave more than one limit) 120%Note: 29% set a maximum O_2 contentof 3% average.E. Will you make any repairs in thehydrogen box while running? (20)No67%No welding14%Limited repair5%Yes9%F. When shutdown, will you do hotwork in H_2 box without emptyinginsulation (in a cavity)? (20)Yes43%No52%Note: There was no apparent correlation between the source of feed gasand the answers to question E and F.G. What type of insulation do youhave in H_2 box? (21)Rockwool or Mineral wool81%H. Do you purge the air out of processequipment before introducingflammable materials? (21)Yes100%I. Purging process equipment: Whatdo you use for purge? (21) N_2 100%	No fixe	d limits	24%
H_2 1%; 4%; 10wer explosivelimit14%CO-10 ppm5% $O_2-0\%$; 2%; 4%; 5%; 5%29%No answer24%(Some gave more than one limit) 120%Note: 29% set a maximum O_2 contentof 3% average.E. Will you make any repairs in thehydrogen box while running? (20)No67%No welding14%Limited repair5%Yes9%F. When shutdown, will you do hotwork in H2 box without emptyinginsulation (in a cavity)? (20)Yes43%No52%Note: There was no apparent correla-tion between the source of feed gasand the answers to question E and F.G. What type of insulation do youhave in H2 box? (21)Rockwool or Mineral wool81%H. Do you purge the air out of proc-ess equipment before introducingflammable materials? (21)Yes100%I. Purging process equipment: Whatdo you use for purge? (21)N2100%	Non-exp	plosive	24%
CO-10 ppm 5% $O_2-0\%$; 2%; 4%; 5%; 5% 29% No answer 24% (Some gave more than one limit) 120% Note: 29% set a maximum O_2 content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	$\Pi_2 \perp v;$	4%; lower explosive	149
$\begin{array}{llllllllllllllllllllllllllllllllllll$	CO-10	ppm	5%
No answer 24% (Some gave more than one limit) 120%Note: 29% set a maximum O_2 contentof 3% average.E. Will you make any repairs in thehydrogen box while running? (20)No67%No welding14%Limited repair5%Yes9%F. When shutdown, will you do hotwork in H ₂ box without emptyinginsulation (in a cavity)? (20)Yes43%No52%Note: There was no apparent correlation between the source of feed gasand the answers to question E and F.G. What type of insulation do youhave in H ₂ box? (21)Rockwool or Mineral wool81%H. Do you purge the air out of processequipment before introducingflammable materials? (21)Yes100%I. Purging process equipment: Whatdo you use for purge? (21)N ₂ 100%	O ₂ -0%;	2%; 4%; 5%; 5%	29%
(Some gave more than one limit) 120% Note: 29% set a maximum O_2 content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	No ansv	wer	24%
Note: 29% set a maximum O_2 content of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	(Some)	roug more than one line	
of 3% average. E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	Note: 2	29% set a maximum $\Omega_{\rm s}$	content
E. Will you make any repairs in the hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	of 3% av	verage.	content
hydrogen box while running? (20) No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	E. Will	you make any repair	s in the
No 67% No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H_2 box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	hydroge	en box while running?	(20)
No welding 14% Limited repair 5% Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	No No sual	1	67%
Yes 9% F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	Limited	ling	14%
F. When shutdown, will you do hot work in H ₂ box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H ₂ box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N ₂ 100%	Yes	теран	0%
work in H_2 box without emptying insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	F. Whe	en shutdown, will you	do hot
insulation (in a cavity)? (20) Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	work i	n H ₂ box without e	mptying
Yes 43% No 52% Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	insulatio	on (in a cavity)? (20)	
Note: There was no apparent correla- tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	Yes No		43%
tion between the source of feed gas and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	Note T	here was no apparent	52%
and the answers to question E and F. G. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	tion be	tween the source of f	feed gas
C. What type of insulation do you have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	and the	answers to question H	and F.
have in H_2 box? (21) Rockwool or Mineral wool 81% H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	G. What	at type of insulation	do you
H. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	have in	H_2 box? (21)	
1. Do you purge the air out of proc- ess equipment before introducing flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	H Do	or Mineral wool	81%
flammable materials? (21) Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	ess en	upment before int	or proc-
Yes 100% I. Purging process equipment: What do you use for purge? (21) N_2 100%	flammal	ole materials? (21)	outeing
I. Purging process equipment: What do you use for purge? (21) N_2 100%	Yes	(41)	100%
do you use for purge? (21) N_2 100%	I. Purgi	ing process equipment	t: What
N ₂ 100%	do you	use for purge? (21)	
	N ₂		100%