Air Products and Chemicals INC.

ESCAMBIA PLANT

INTEROFFICE MEMORANDUM

comments
2-9-84 + 2-10-84
WHM

F Escambia

To: Distribution

Date: 5 October 1977

Copies:

From: W. J. Stueben

Re: PVC Process Hazards Review Summary

Attached is your copy of the PVC Process Hazards Review Summary. It is presented in this form by agreement of the committee members.

All members of the committee were given an opportunity to review the rough draft. Their comments are reflected in this document.

This summary, then, represents the views and efforts of the entire committee.

Response by R. E. Gilbert to the Escambia Plant Safety Department is requested by copy of this letter by 4 November 1977.

W J Stueben

W. J. Stueben

WJS:jsr

Distribution:

R. E. Jones
R. E. Gilbert
G. D. Hardy
J. C. Novak
C. V. Hildenbrand
L. S. Forester
A. L. Junek
M. Langsam
W. C. Robb
G. Sanderson
G.B.H. Speed
T. Sreenivasan
W. C. Wilde

OCT 10 1977

AP00030096

PVC PROCESS HAZARDS REVIEW

Introduction

A review was undertaken to reveal the major hazards inherent in the PVC Plant as it existed after the recent expansion. Hazards were considered to be those things that would cause personal injury, VCM release, or loss of equipment.

The committee performing the review consisted of the following:

A. Junek - Maintenance Engineer - Escambia Plant
M. Langsam - R&D Chemist - Allentown
W. Robb - Process Engineer - Escambia Plant
G. Sanderson - Project Engineer - Calvert City Plant
G. Speed - PVC Process Supervisor - Calvert City Plant
T. Sreenivasan - R&D Engineer - Allentown
W. Stueben - Safety Engineer - Escambia Plant
W. Wilde - PVC Process Engineer - Escambia Plant

The review was done over a period of 11 working days, a little over 600 man-hours. Time was spent both in the plant observing and in conference.

The Method

The method of investigation chosen was the "What If" method. As the review progressed; however, Failure Mode Analysis was integrated into the method in the questions. The "Failure Rates For Use In Fault Tree Analysis" document published by DuPont was used extensively to determine probability of occurrence and whether or not a recommendation was indicated at this time.

The committee decided that the review would be comprised of the various parts of the PVC manufacturing facility that were actually involved in the conversion of Vinyl Chloride Monomer to PVC. The drying, warehousing and loading of PVC resin were not included because of the time available and apparent lesser degree of hazard involved. The chemical cleaning unit was not included because many details of its operation were not firmed up yet. It will be reviewed at a later date.

Each review of a part of the plant was done in three stages. The part or process being investigated was first described. The "What If" questions were then asked in roundtable fashion and the answers written down. When it became apparent that the period of questioning was over, all of the questions asked and their answers were reviewed and recommendations made. Everything any member of the committee thought of was considered and written down. This proved to be an effective system in that on some occasions, a question originally relegated to relative unimportance, turned out to have much greater significance at a later time.

Because of this, all of the situations considered credible by members of the committee are included in this report. Although they may not have been considered significant by the members of the committee at the time of the review, some of them may prove to be important to someone else under a different set of circumstances.

The review of the plant was divided into the following parts:

- Vinyl Chloride Monomer Unloading
- Vinyl Chloride Monomer Storage
- Vinyl Chloride Monomer Charging System
- Reaction Run
  - General Purpose Resin
  - Pearl Resin
- Short Stop System
- Vinyl Chloride Monomer Recovery System
- Stripping
  - Continuous
  - Batch
- Chemical Cleaning A Reactor
- Initiator Handling

SUMMARY OF RECOMMENDATIONS

Vinyl Chloride Monomer Unloading

1. The following should be provided on a written checklist for the operator to use prior to unloading each VCM railcar:

   a) Proper spotting technique (must be within one foot of designated spot).
   b) Car has proper identification.
   c) Chocks and brakes are set properly.
   d) Connection of vapor and liquid lines are satisfactory.
   e) Grounding wire is connected.

?
these are in procedure [illegible] form

2. Vapor line at loading station should be pressure checked annually to ensure steam jacket integrity. Leak patrol & fixed monitors are used in lieu of this recommendation

3. A second flow switch should be provided on the VCM pump with the contacts in series so that if the first switch malfunctions, the pump will still shutdown and not overheat. Double Mech Seal eliminates overheating at pump seal, with Auracell unit ~~[illegible] will be installed on pump also~~

4. A list of vents that lead from the unloading and recovery systems to the gas holder should be provided to facilitate checking in the event that a vent is left open. (If a vent from unloading is left open, the gas holder will fill and then the recovery system will load up resulting in the inability to recover Vinyl Chloride from the rest of the plant.)

Valve "frosting" is evidence of valve open

AP00030098

5. The Chicksan joints on the loading arms should be inspected thoroughly at the beginning of each loading period. They should be replaced or repaired at any indication of excessive wear or malfunction. In Procedure

6. All drains and bleed valves in the system should be checked on the current leak patrol to pick up any that are leaking and are resulting in emissions. Leakers should be carefully checked by Maintenance to determine if failure is likely. In Procedure

7. A rupture disc should be added to the compressor relief valve to ensure that it meets EPA regulations and to minimize malfunction due to plugging. Complete

Vinyl Chloride Monomer Storage

1. Sight glasses on the monomer storage tanks should be checked for the presence of ball check valves. If not present, they should be installed. If present, their ability to function should be checked. The ball check valves minimize any release in the event a sight glass breaks. At the time of the review, the committee could not find anyone who knew if they were there or working.
   Continuing recommendation

2. Code and insurance requirements should be checked for the use of excess flow valves or other automatic shut-off devices in lines coming from the storage tanks. The concern here is that if a line ever ruptured or was broken by an outside source (lift truck, carrydeck crane, etc.) the entire contents of the storage tanks could spill onto the ground.
   Continue to but do not use xs flow checks

VCM Charging System

1. The following recommendations were arrived at to minimize the chance of a major overcharge of vinyl chloride to a reactor.

   a) The charge meters should be zeroed no less than once per week.
   OK b) The computer should be programmed to check weigh tank loss versus charge meter indication.
   c) Consideration should be given to installing level indicators on each reactor.
   (b) and (c) also apply to charging meter failure.

2. The limit switch that tells the computer the charge pot lid is down and locked should be checked daily to make sure it is set properly. This could easily be done by the Operator on the first charge of the day. An unlocked lid, indicating that it is locked, could result in a considerable Vinyl Chloride emission.

3. The authorization of equipment function overrides in the computer programs should be limited to certain personnel. The overrides in current use should

be maintained in a log and a daily override check should be made of the computer. The concern here was that the use of overrides, although essential in a computerized plant, could become a hazard itself if proper controls are not established and maintained.

OK

4. To keep an Operator from putting initiator in the wrong charge pot, it is recommended that the sequence of operations be changed so that a vacuum is maintained on the charge pots except when adding initiator. This procedure would also aid in addressing other concerns the committee had:

OK

a) Detection of a vacuum breaker leak.
b) Detection of a leak through one of the monomer charge valves.
c) Detection of a leak in the steam jet valve.
d) Detection of a leak through the bottom valve of the charge pot.

5. A computer check, that enough vinyl chloride is available for a charge, currently begins after initiator is put in the charge pot. It is recommended that this check by the computer be done <u>before</u> the initiator is put in to minimize the time the initiator is in the charge pot. (Only one reactor can be charged at a time. If the vinyl charging system is in use on another reactor, the initiator has to wait in a possibly warm charge pot to be dumped into the reactor.)

OK

6. A recirculating line should be installed on the fresh vinyl charge pumps to eliminate the chance of overheating in the event the automatic system designed to shut it off does not work and the pump deadheads.

OK

7. Although the detection of a problem of overheating is less with the recovered vinyl charge pump because of its more frequent use and the fact that its filters have relief back to the pump suction, another problem came up when reviewing the pump's specifications. The monomer filter relief is currently set at 190 PSIG. This setting should be lowered to 110 PSIG based on available pump pressure. (Differential pressure should be used as the setting, not absolute as was done.) Continue or check to see if done

8. If the bottom charge pot valve plugs as vinyl chloride monomer is introduced into the charge pot, a rapidly accelerating reaction and possible explosion could result from the reaction of the vinyl chloride and initiator already there. (Buildups of PVC around the bottom charge pot valve have been observed at the Calvert City Plant.) The recommendation is that the computer be programmed to "go into emergency" if the amount of vinyl chloride that should have registered on the meter in a set time period, has not registered. This time period should be based on the rate of reaction of pure vinyl chloride monomer and initiator and should not be greater than one minute.

Concern by every member of the committee about the charge pot operation in general, resulted in the recommendation that consideration be given to introducing vinyl chloride directly into the reactor and washing the initiator into the reactor with water.

Further experience @ both plants says this is not what to do

Reaction Run Operation

These recommendations cover the period of time from the start of the polymerization reaction until the reaction is complete and the PVC slurry is discharged to a stripper.

1. A short discussion was held about the effects of a power failure after the reaction goes exothermic. It was decided to recommend that power failures in the plant be the subject of a separate "second generation" review using Failure Mode Analysis. This was done because of the amount of time it would take to do the job properly and the time remaining for the committee to complete the review due to other commitments.

Continue

& down

2. Area VCM monitoring points should be installed at the top of the cooling tower (PVC), the cooling tower return sump and the chilled water return sump so that a leak in either the condenser on top of the reactor or a cracked baffle would be detected as soon as possible.

3. OK Operator training should emphasize initiator recognition and selection. If the wrong initiator is selected for certain recipes, a batch could overheat.

4. OK Operator training should include the possibility that a reaction running hotter than normal could be caused by a plugged gas vent on the condenser of a large reactor. This would be particularly true if the reaction in question occurred immediately after an opening of the reactor.

5. withdraw this PHR The computer should be programmed to detect simultaneous very low RPM and lower than normal amperage on the agitator drive motor and short stop the batch. This would allow the suspension in the reactor to still mix short stop through the entire reactor effectively (without having to boil the batch) in case of a broken agitator shaft or coupling. This recommendation also applies to situations that cause the motor to kickout because of overload or power "dip".

6. OK Training for the field operator should include the fact that steam hammer in the reactor could be caused by a reactor cooling jacket water pump failure or a chilled water valve that has failed open.

7. OK Rapidly rising batch temperature could occur if the automatic valve controlling the steam to the reactor jacket failed open. Operator training should include this information to enable computer operator to diagnose a high temperature situation.

8. On the large reactors and stripper, an agitator shaft Duraseal system failure could result in some or all of their contents being spilled onto the ground. Although this would probably happen in stages starting with the failure of the upper seal and could be detected by a loss of seal fluid from

the reservoir, the common reservoir, if allowed to empty, would quickly result in the failure of the seal systems on the two large reactors and the stripper. Because of the potential, the following is recommended:

a) Install a low level alarm on the seal fluid reservoir and flow indicators on the individual seal systems, or preferably, — in place — not useful

b) Install individual Duraseal systems on the three vessels with bottom entering agitators with the above alarms, flow indicators and use circulating pumps. — Not necessary determined thru experience

The "old" reactor building vessels, with top entering agitator shafts, have a mixed bag of seal systems. Three reactors and one batch stripper are on a common system while the remaining vessels have individual systems that are operated under nitrogen pressure. While the results of a seal failure on the common system would be slightly different than the bottom entering agitators, more gas escape (VCM) and less slurry, the recommendations are the same. The nitrogen pressured systems might fail slower. A failure could result in the pressurization system filling with VCM - a difficult problem to handle. The recommendations, however, are the same as for the other systems. Minimum action should be low level alarms on the existing reservoirs and flow indicators on each system. Preferably each vessel should have its own pumped Duraseal system to minimize the results of a seal system failure.

Flow indicators have another benefit. If a seal system were blocked in or the seal fluid pump were not turned on, detection would be much easier.

It should be noted that the Duraseal systems on #19 reactor at the Calvert City PVC Plant have interlocks on the agitator motors that do not allow them to be turned on without the seal fluid pumps operating.

9. Area monitoring points should be installed at the base of all reactors to detect a leaking drop valve. Significant leaks have occurred when the drop header valve leaks outside the system after being opened. — Complete

10. A visual check should be made by an Operator after each batch (through the sight glass) to make sure the reactor is completely empty. If enough slurry were left in a reactor after dropping, overpressure could result on the next batch. — OK Complete

11. Although no member of the committee could remember ever hearing of a reactor rupturing, the committee recommends that initial acoustic emission testing be done on each vessel and repeated every ten years. The chance of rupture is very remote, but the results would be disasterous. — ?

The Short Stop System

1. There are a number of block valves in the short stop system that if closed,

would prevent the short stopping of a problem batch. It is recommended that these valves be carsealed open and the seals checked periodically (at a frequency to be determined).

2. A meter is used to register the amount of short stop used and all short stop flows through it. In order to preclude any problems in this area, the following recommendations are made:

   a) Carsealed bypass valves should be installed around the meter in case it plugs or jams.
   b) A filter should be installed in the line between the short stop pump and the reservoir to prevent contamination from plugging or jamming the meters.
   c) A spare meter should be folioed (not currently done). inventory

   These recommendations would increase the reliability of the short stop system.

3. If an Operator tries to manually short stop more than one batch simultaneously, limitations in the system might cause one reactor not to get enough short stop to kill the batch. Operators should be instructed to short stop one batch at a time, the same as if the computer were doing it. Done

4. A low level alarm should be installed on the short stop fluid reservoir to ensure that enough short stop is always available. One third of volume is recommended as set point. Done

5. The sight glass (level indicator) on the short stop reservoir should be checked for the presence of ball check valves. A broken sight glass would render the short stop system ineffective. Continue

6. To ensure nitrogen is immediately available for the system, only one gas bottle should be connected at a time and the other retained as a backup (two are currently connected). The relief valve should be checked for proper size and removed for calibration if it has not been done already. Done

7. Weather tight one gallon cans of short stop should be placed in both the new and old reactor buildings, on the top floors (charge pot level). Short stop could then be introduced manually through the charge pot in case the automatic charge pot system is inoperative, or a line to a particular reactor plugs. Continue (will be done)

8. Reservoir supply pump is rated at 340 635 feet on print. Reservoir to be pumped into is rated ~~200~~ 265 PSI. This discrepancy should be reconciled. Needs to be this way

Recovery System

1. The need for urgency in effecting repairs of vacuum pump water leaks should be included in Operator training. A large water leak would at first

cause the pump to lose its effectiveness and then, if the pump were allowed to continue running, could result in the seal failing and a VCM emission. Operators should be alert to loud squealing noises from the pump as an indication of pump problems.

NA?

2. If the vacuum pump seal water separator overpressures, the prints call for the pressure to relieve back into the separator. This relief path should be checked thoroughly and rerouted or fitted with a rupture disc/relief valve.

Complete

3. If the gas holder level control indicates higher than actual, the compressor recycle valve sticks closed, or the three Nash compressors come on and stay on, a vacuum could be pulled on the gas holder. It is recommended that a limit switch be installed at the low level position of the gas holder piston that interlocks with the compressors. The possibility of using liquid seal protection such as a "Midland Conservent" should also be explored. A "Midland Conservent" is also capable of overpressure protection.

OK

4. If a tube in the seal water exchanger of a compressor were to rupture, VCM would probably show up in cooling tower water. The recommendation to add a VCM sampling point at the top of the cooling tower also applies here. (Reaction Run #2). (This also applies to a condenser tube rupture.)

Done

5. If the compressor seal water were allowed to freeze, the seals could break or leak through resulting in an emission. Freeze checks should be included for the compressors.

OK

6. The sight glass on the seal water separator should be inspected to make sure that check valves are present so that any emission resulting from a broken sight glass is limited.

[illegible]

7. A pressure drop indicator should be installed on the scrubber so that plugging could be detected. As presently designed, a plugged scrubber could result in the gas holder being overpressured. A plug would be difficult to detect prior to a gas holder overpressure.

Tank no longer used as scrubber

8. A loss of cooling of the condensers would result in additional VCM in the inerts bleed. This could be detected if the flow transmitter were set to alarm (at a set point to be determined). This indicator would also help detect the liquid that would result from a plugged rundown line.

OK

9. Steam sparging should be installed in the condenser bleed so that ignition because of lightning can be controlled. The VCM concentration could be in excess of 10 percent (EPA problem?).

OK

10. If the freon level controller on the freon condenser were to indicate lower than actual, liquid could get into the compressor and the seals would fail. Consideration should be given to installing a Knockout pot.

Done

11. Leaks in the gas holder seal might not be detected until after personnel overexposure has occurred. An area monitoring sample point should be installed in the upper portion of the gas holder.

Dcw.

Stripping A Reactor Formulation

No. 1 (Continuous) Stripper

1. A pressure alarm should be installed on the stripper pressure indicator to indicate an overpressure problem prior to the relief valve lifting. An overpressure could occur because of the following reasons:

   Determined to be not necessary

   a) Vent flow control sticks shut or shuts in error.
   b) Too much sparging steam is admitted to stripper.
   c) A batch was sent to the stripper before completion of polymerization and the gas holder is full.
   d) The back pressure control valve fails and does not control.

2. Operators should be instructed to lower the temperature on the stripper to minimize the chance for overpressure when an incompletely polymerized batch is sent to the stripper.

   OK

3. High and low level alarms should be installed on the stripper. A high level alarm would prevent overfilling and possible overpressure because of a failed "bottoms pump" or "bottoms" level controller. A low level alarm would help prevent the stripper from plugging because of the contents being "cooked", by alerting the Operator to the condition.

   Not a hazard

4. The "bottoms line" of the stripper should be inspected at least quarterly after the first six months of operation. The line is made of 304 stainless steel. The 304 stainless steel bottoms line had to be replaced by a 316L stainless steel line at Calvert City because of stress corrosion cracking adjacent to the welds

   and Not a problem

Nos. 2 & 3 (Batch) Strippers NA - no longer batch stripping

1. A Bacharach sensor should be installed above the blend tank that will alarm but not turn on the sprinkler system in the event a batch is sent to the tanks without leaving some in the stripper as a water seal. The 15 foot head created by the piping should minimize any release but it was felt that the 20 minute time between area monitor system samplings was insufficient. This sensor would also detect a release caused by a level controller failure that allowed VCM to come from the gas holder through the stripper.

   VA - w

2. The four way valve that VCM flows through to the gas holder has a history of leaking through the stem. Any new valve that is ordered should be watched carefully for similar problems.

3. The rubber boots on the oversize line from the wet screen can plug and break, releasing hot slurry on anyone who happens to be underneath. These boots should be checked for integrity on a frequent basis.

Done

Chemical Cleaning A Reactor

1. An area monitor point should be installed in the vent line from the DMF storage tanks to detect VCM in the DMF that might occur from a valve leaking through.

NA

2. If the vacuum breaker leaks through during chemical cleaning, DMF vapors and liquid would be sent to the atmosphere. A leak through of the stem jet valve would allow DMF to collect inthe jet and spray out as hot liquid and vapor during the next use. Both of these valves should be replaced at the first sign of any leakage.

OK

3. If the reflux condenser valve were to leak through or be left open (i.e., during the manual drop of a batch) vinyl chloride could leak back into the reactor. It is recommended that a checklist be provided (the computer sequence would do) to aid an Operator in dropping a batch manually. Any condition that indicates that this valve might be leaking should result in the valve being changed.

Not a hazard
Done

4. Calvert City has had problems with the agitator shaft seals leaking through after chemical cleaning. Run batch recommendation #9 also applies here.

Done

5. Water could get into the gas holder if the meter controlling the water fill prior to cleaning was in error. If enough water was allowed to get into the gas holder, problems of overstressing the gas holder could occur. It is recommended that this operation be timed by the computer.

NA

6. All manway and charge pot O rings should be replaced after every cleaning as DMF attacks the material they are currently made of.

It now [illegible] DMF [illegible] attack current O rings

Initiator Handling

1. The storage freezer alarm that is currently in the third floor fresh air room of the old reactor building should be moved to the control room, as Operators no longer stay in this room continuously.

Done

2. The thermostats controlling the storage freezers should be converted to explosion-proof models. The chance of VCM being ignited is now much greater because of the gas holder and the size of the new reactors.

Done

The charge pot and its operation was probably the greatest cause of unanimous concern. To this end, Mike Langsam is currently doing research on the explosion potential of the peroxides and peroxide VCM combinations in the charge pot.

If more detail is needed, it can be obtained from a committee member. The rough notes used to make this summary are also available if requested.

W. J. Stueben

W. J. Stueben

WJS:jsr

10/4/77

Bill MacNair

FAULT TREE INDEX

REACTOR RELEASES - RUNAWAY REACTIONS

Introduction

A fault tree describing all the combinations of events which could cause a VCM release was not developed for this review because of the complexity of the various runaway reaction demand scenarios. Instead, a different approach was attempted. The stepwise overview of this procedure is as follows:

(1) A list of all the individual demands was generated.

(2) A list of all the possible levels of protection, including alarms and operator intervention were described. Average unavailabilities were calculated for each of the individual protective system components.

(3) For each particular demand a set of minimum cut sets were developed describing the necessary and sufficient combinations of individual protective system component failures.

(4) The total protective system unavailability for each individual demand was calculated.

(5) The individual demand rates were then multiplied by their respective protective system unavailabilities to obtain individual event frequencies.

(6) Individual event frequencies were then summed to obtain the total frequency for reactor release from runaway reaction.

Discussion

Table I contains a listing of the various ways deviatins in normal operation could occur which if undetected and not controlled could lead to runaway reactions and reactor releases.

Table I

	DEVIATION	DETECTION	PROTECTIVE SYSTEM
A	Wrong type initiator	Jacket T drops	1) Full reflux cooling 2) Control by small additions AMS + venting if required 3) Manual AMS dump
B	Wrong amount of iniator	Jacket T drops	Same as A
C	Excessive fouling	Jacket T drops Reactor P and T increases	Same as A
D	Loss of cooling water supply (other than cooling water supply going dry)	"No flow" signal from flow transmitter	1) Automatic switch to chilled water 2) Control by small additions of AMS + venting if required 3) Manual AMS dump
E	Chilled water supply fails	Reactor P & T increases	1) Manual switch back to cooling tower water 2) Full reflux cooling 3) Control by small additions of AMS + venting if required 4) Manual AMS dump
F	Cooling tower sump goes dry	Jacket T drops Reactor P & T increases Computer printout Alarm in CR	1) Automatic switch to chilled water (temporary only) 2) Control by small additions of AMS + venting if required 3) Manual AMS dump
G	Too much suspending agent	Jacket T drops AMP rise	1) Addition of water same as A
H	Monomer overcharge	Review of charge data Jacket T drops AMP rise	Same as A
I	Water under charge	Jacket T drops AMP rise	Same as G

J	Agitator failure	Low AMPS computer and panel alarm Low RPM computer alarm	1) Try to restart 2) Must add AMS within 20 seconds (P=0)
K	Power failure		1) Must add AMS within 20 seconds (P=0)
L	Temperature control system failure	Jacket T drops reactor P & T increases	Same as A
M	Instrument air failure		1) Automatically fails to cooling tower water and full reflux

Table II contains a listing of all the various deviations (demands) which could lead to a runaway reaction and calculated frequencies.

Table II

	Demands Leading to a Runaway Reaction	D yr-1
A	Wrong type of initiator	3
B	Wrong amount of initiator	3
C	Excessive fouling	250
D	Loss of cooling water (other than CTW sump going dry)	0.2
E	Chilled water system failure	0.67
F	Cooling tower water sump goes dry	
G	Too much suspending agent A)D	3
H	Monomer overcharge	1.5
I	Water undercharge	1.5
J	Agitator failure	0.4
K	Power failure	0.27
L	Temperature control system failure/steam valve sticks open	0.33
M	Instrument air failure	0.2

The basic assumptions used in deriving the demand rate was that there would be 12 batches per day and a total 3000 batches per year from a total of four reactors. The derivations for these demand rates are included in the Appendix and are based on plant experience and estimates of human error. The high demand rate for excessive fouling is based on an assumption that the last batch prior to chemical cleaning, in this case the 12th batch, will have sufficient fouling as to be difficult to control.

A detailed representation of the ways in which the protective system can fail is shown in Table III. The first column represents failures in the protective system early in the runaway process while the last column represents last ditch efforts to stop the batch. In this representation and the present plant operation there is no automated trip system for shortstop addition. All of the actions taken to stop a runaway require some operator intervention.

Table III

PVC PROTECTIVE SYSTEM FAILURE CAUSES WHICH IN COMBINATION COULD LEAD TO A RUNAWAY REACTION AND VCM RELEASE

1 Temperature sensing/transmission fails

2 Pressure sensing/transmission fails (monitoring)

3 Computer printers fail

4 Operator does not Respond to computer messages

5 Operator responds but chilled H_2O/reflux cooling failed or ineffective

6 Computer annunciator fails

7 Operator does not respond to computer annunciator

8 Operator responds but AMS/vent system ineffective

9 Hardwired temp and pressure alarms fail

10 Operator does not respond to hardwired alarms

11 Manual AMS dump fails or ineffective

Failures from these various columns in Table III were grouped together to form a collection of minimum cut sets specific for each demand.

Not all demands have the same level of protection and therefore the same minimum cut sets. Included in Appendix is a listing of minimum cut sets specific for demands A, B, and C in Table III.

From failure rate and repair information and plant experience average unavailabilities were caluclated for each of the items in the protective system. The relevant calculations and a tabulation of this information is shown in Appendix .

The average unavailability was caluclated for each minimum cut set and for each demand. The average unavailability for a cut set is the product of the average unavailability of the individual items or components.

$$\overline{P}_{cut\ set} = \overline{P}_1 \cdot \overline{P}_2 \cdot \overline{P}_3 \cdots\cdots \overline{P}_i$$

The average unavailability for the protective system relative to a particular demand is

$$\overline{P}_{Protective\ System} = 1-(1-\overline{P}_{cut\ set\ 1})(1-\overline{P}_{cut\ set\ 2})\cdots\cdots(1-\overline{P}_{cut\ set\ j})$$

Table V presents the summary results of potential reactor releases from each of the individual demands. The event frequency for each demand was obtained by the relatinship

$$\overline{\lambda}_A = D_A \cdot \overline{P}_A$$

The table shows a total potential VCM emergency red case rae of 2.1 per year. Of this total 1.7 or approximately 80% of the potential releases are related to decreased heat removal capability requiring close operator attention.

Another 12% of the total is due to either agitator failure or power failure for which there is really no protective system.

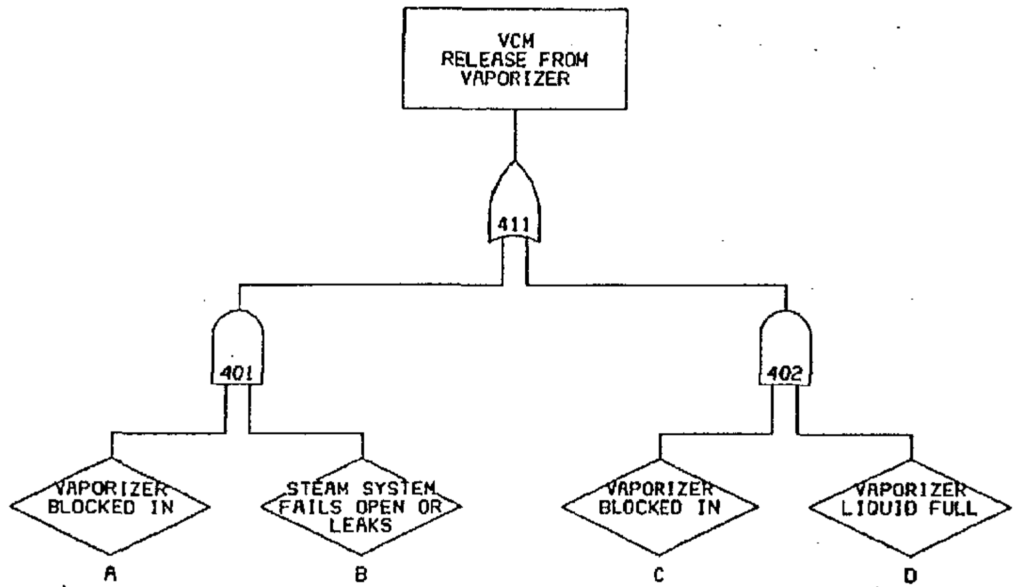
Table IV

PVC REACTOR RELEASE FREQUENCY FROM RUNAWAY REACTIONS
(Without Automatic Shortstop System)

		D (yr^{-1})	Probability P Total Cut Sets	λ (yr^{-1})
A	Wrong type of initiator	3	0.0067	0.020
B	Wrong amount of initiator	3	0.0067	0.020
C	Excessive fouling	250	0.0067	1.68
D	Loss of cooling water (other than CTW sump going dry)	.2	0.0067	0.001
E	Chilled water system failure			
F	CTW sump goes dry	0.67	0.0379	0.025
G	Too much suspending agent	3	0.0067	0.020
H	Monomer overcharge	1.5	0.0195	0.029
I	Water undercharge	1.5	0.0195	0.029
J	Agitator failure	0.1x4	0.364	0.145
K	Power failure	0.067x4	0.364	0.098
L	Temperature control system failure/steam valve sticks open	0.33	0.0379	0.012
M	Instrument air failure	0.2	0.084	0.017
			Total	2.1

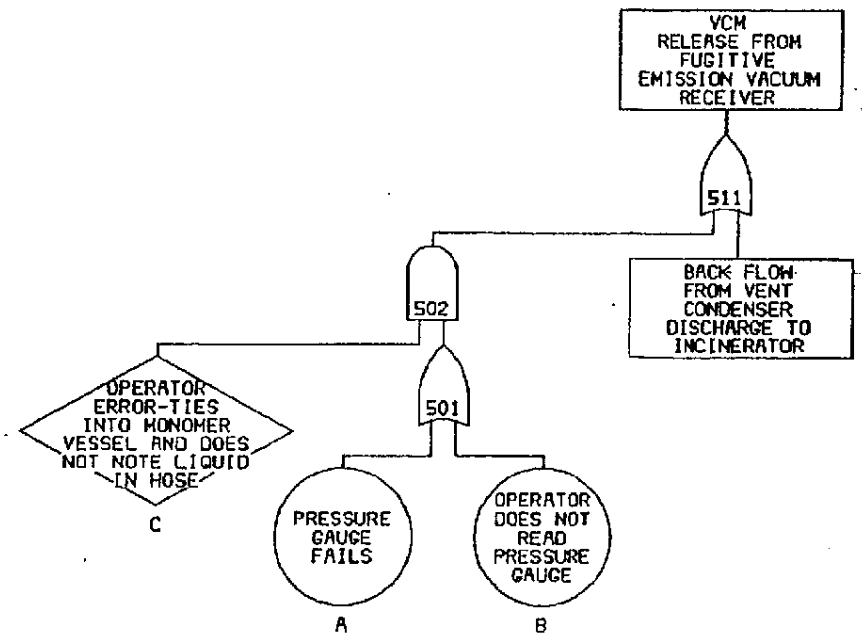
Condenser System Failure
(associated w/ excessive fouling)

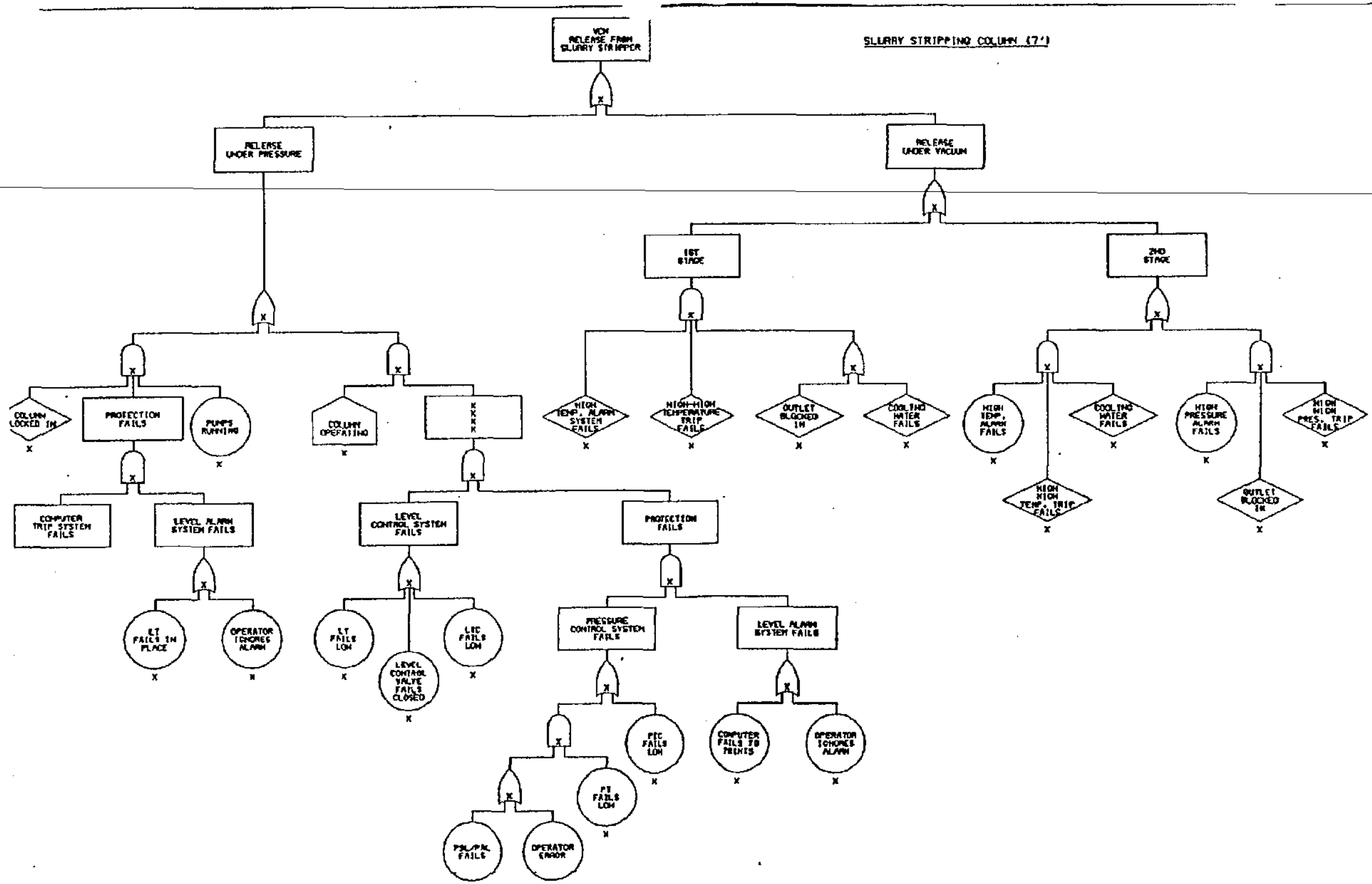
AP00030114


VCM
RELEASE FROM
VAPORIZER
411
401
402
VAPORIZER
BLOCKED IN
A
STEAM SYSTEM
FAILS OPEN OR
LEAKS
B
VAPORIZER
BLOCKED IN
C
VAPORIZER
LIQUID FULL
D

T00076

FUGITIVE EMISSIONS

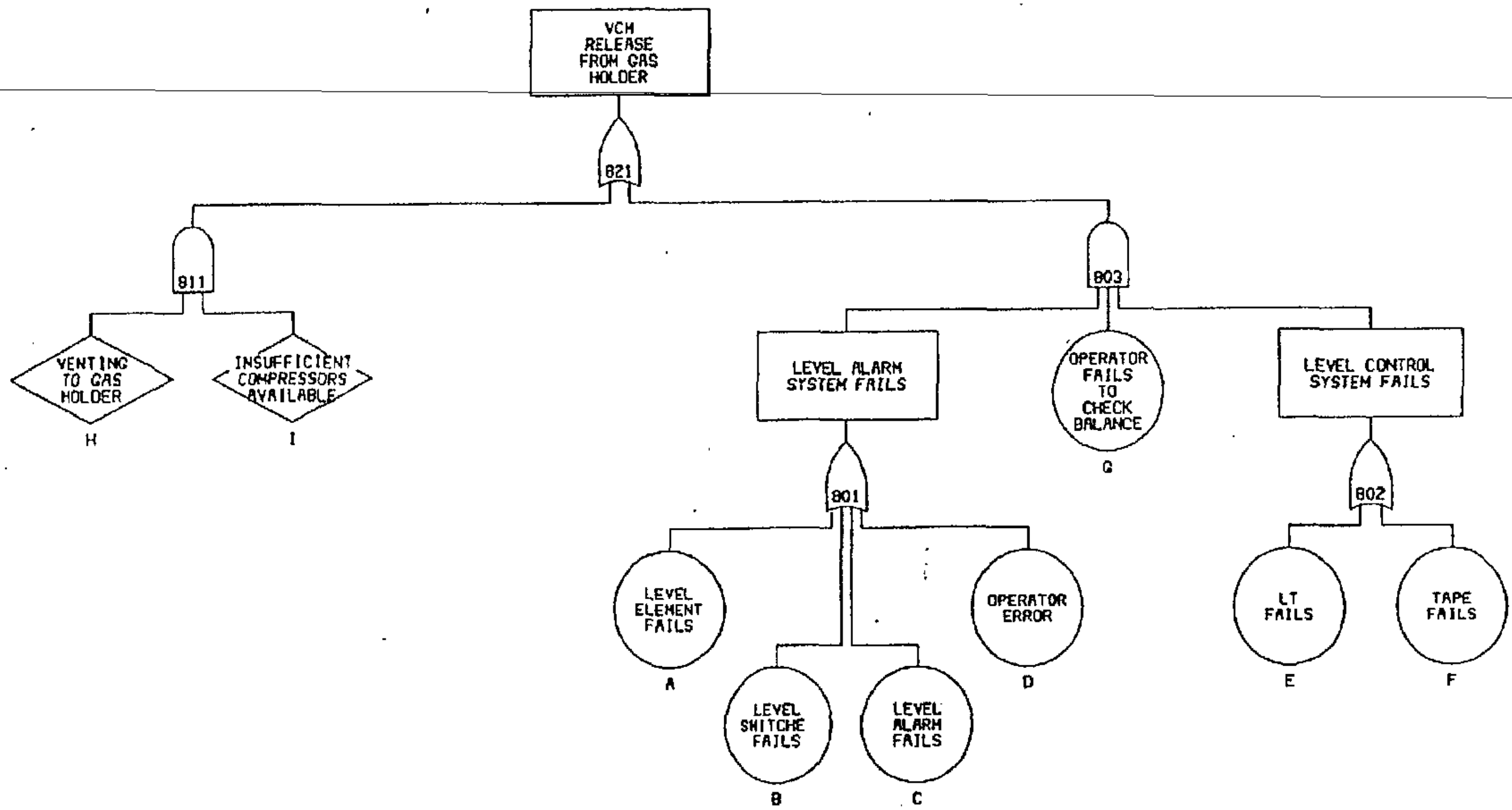




T30075

AP00030117

GAS HOLDER

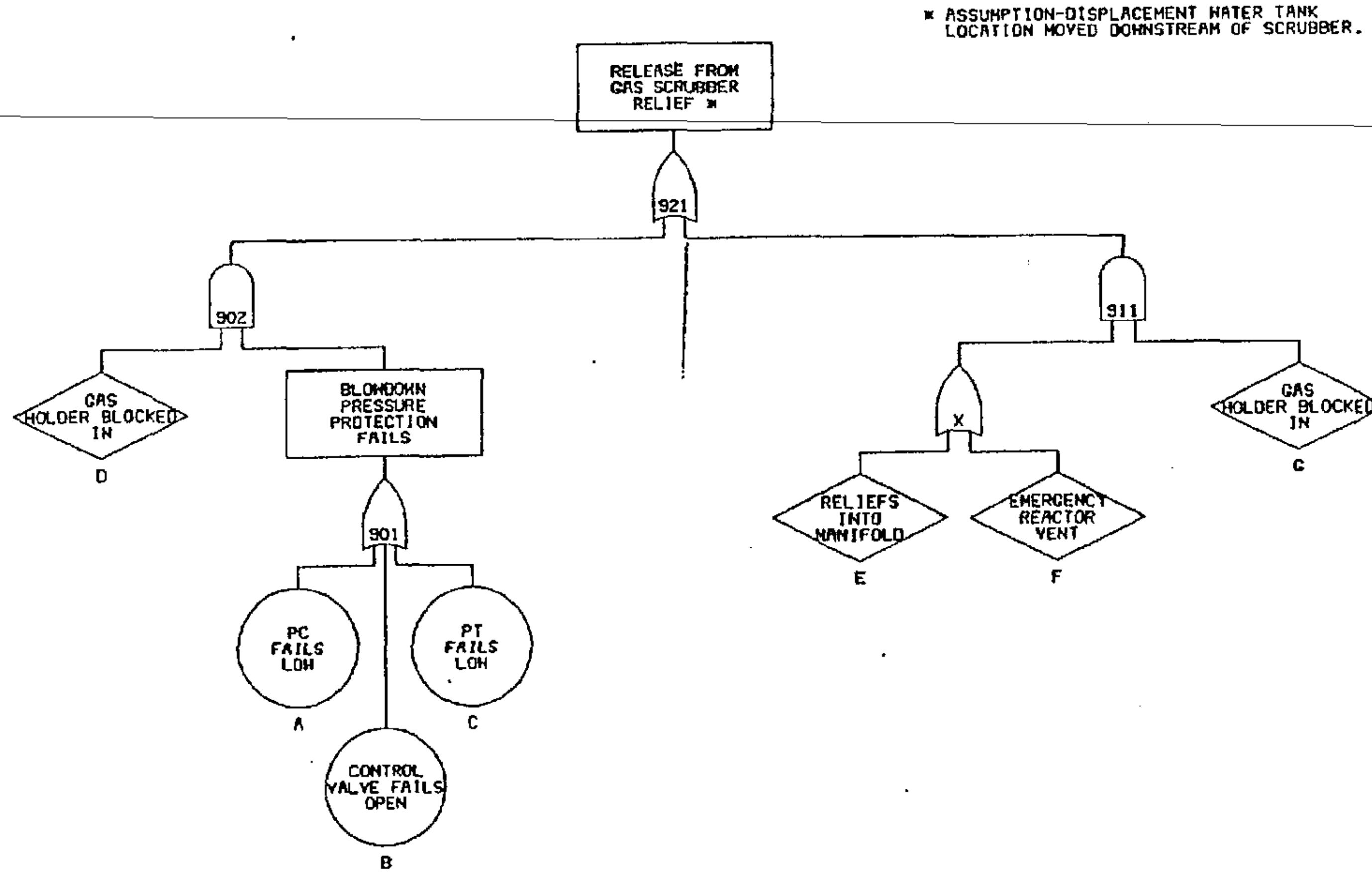


NOTE:
GAS HOLDER - HOLDS 1 1/2 BATCHES

T30060

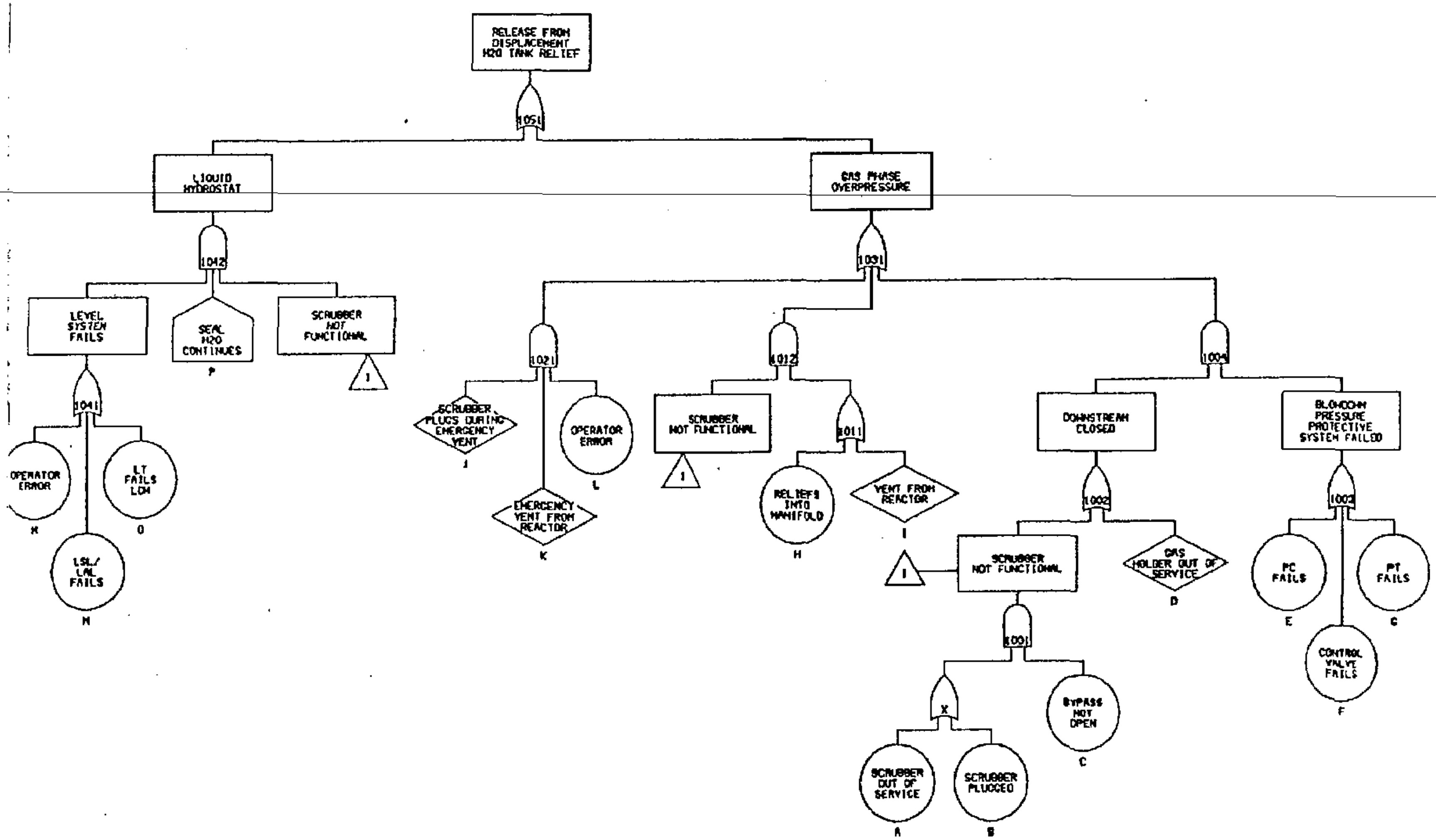
AP00030118

GAS HOLDER INLET SCRUBBER



T30091

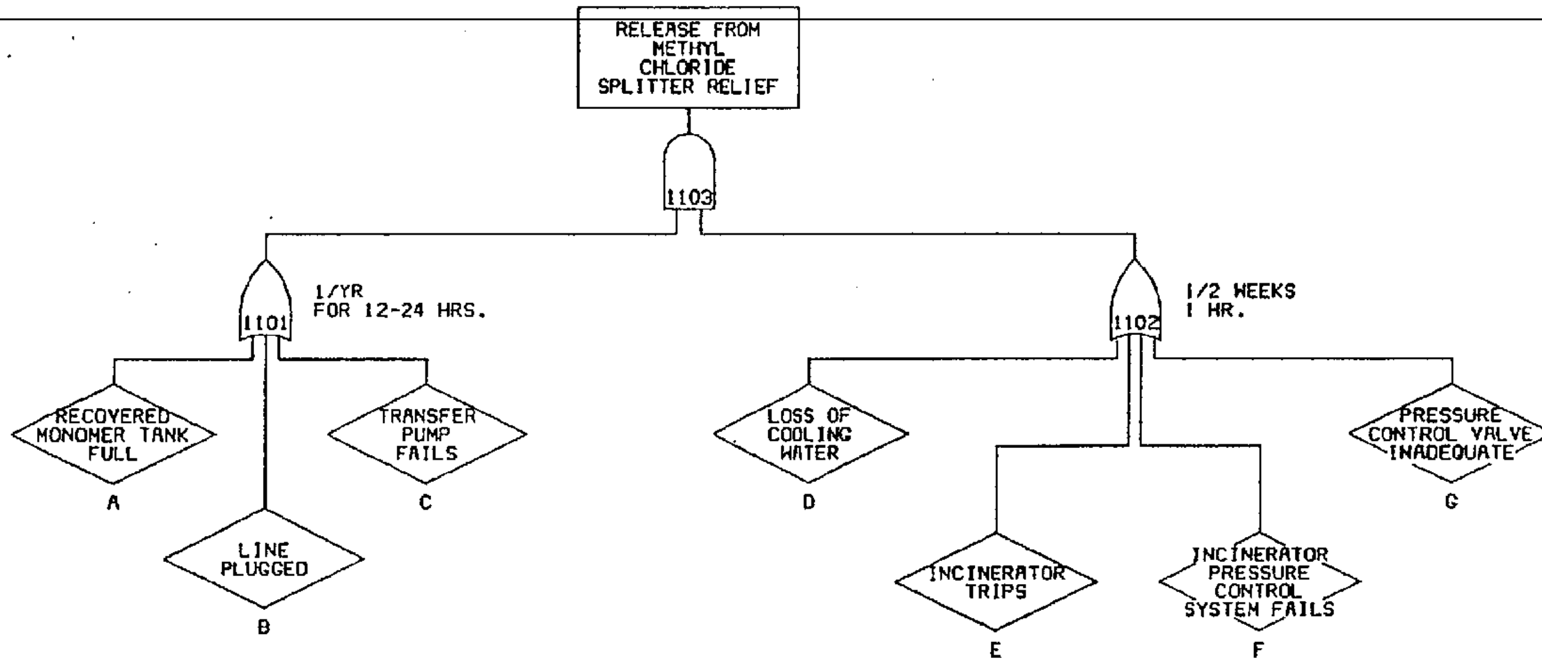
AP00030119



T300B2

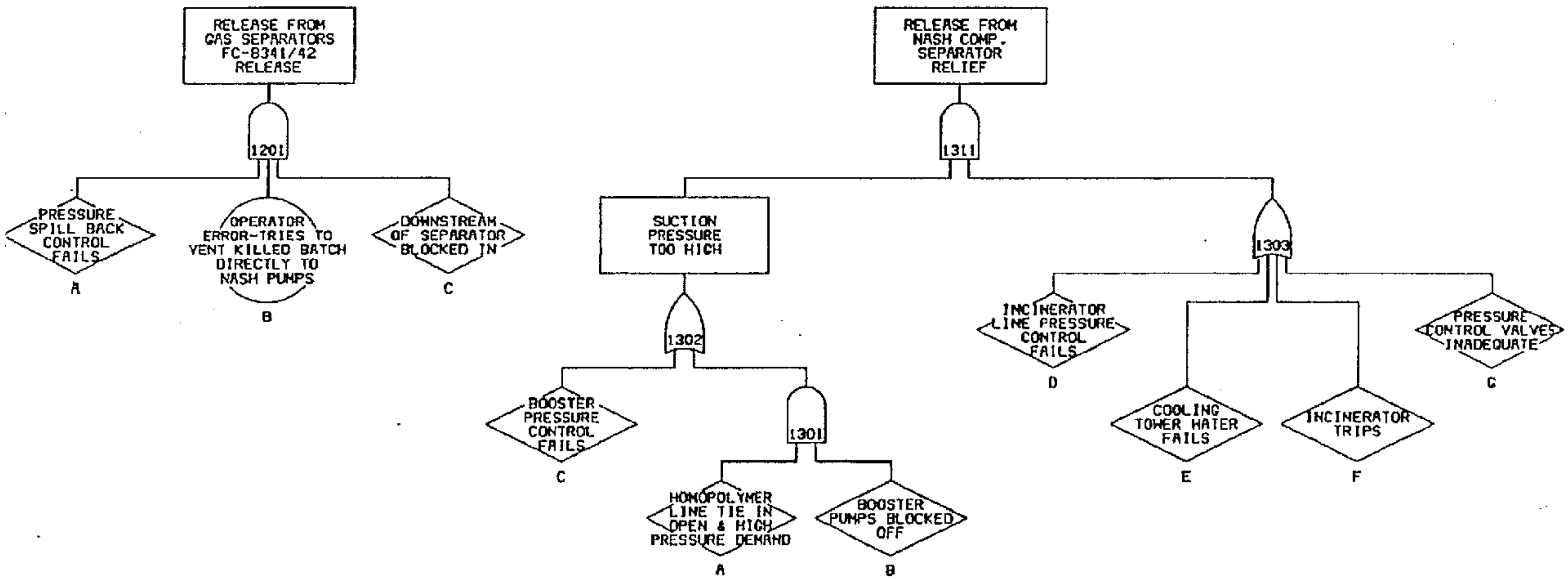
AP00030120

METHYL CHLORIDE SPLITTER

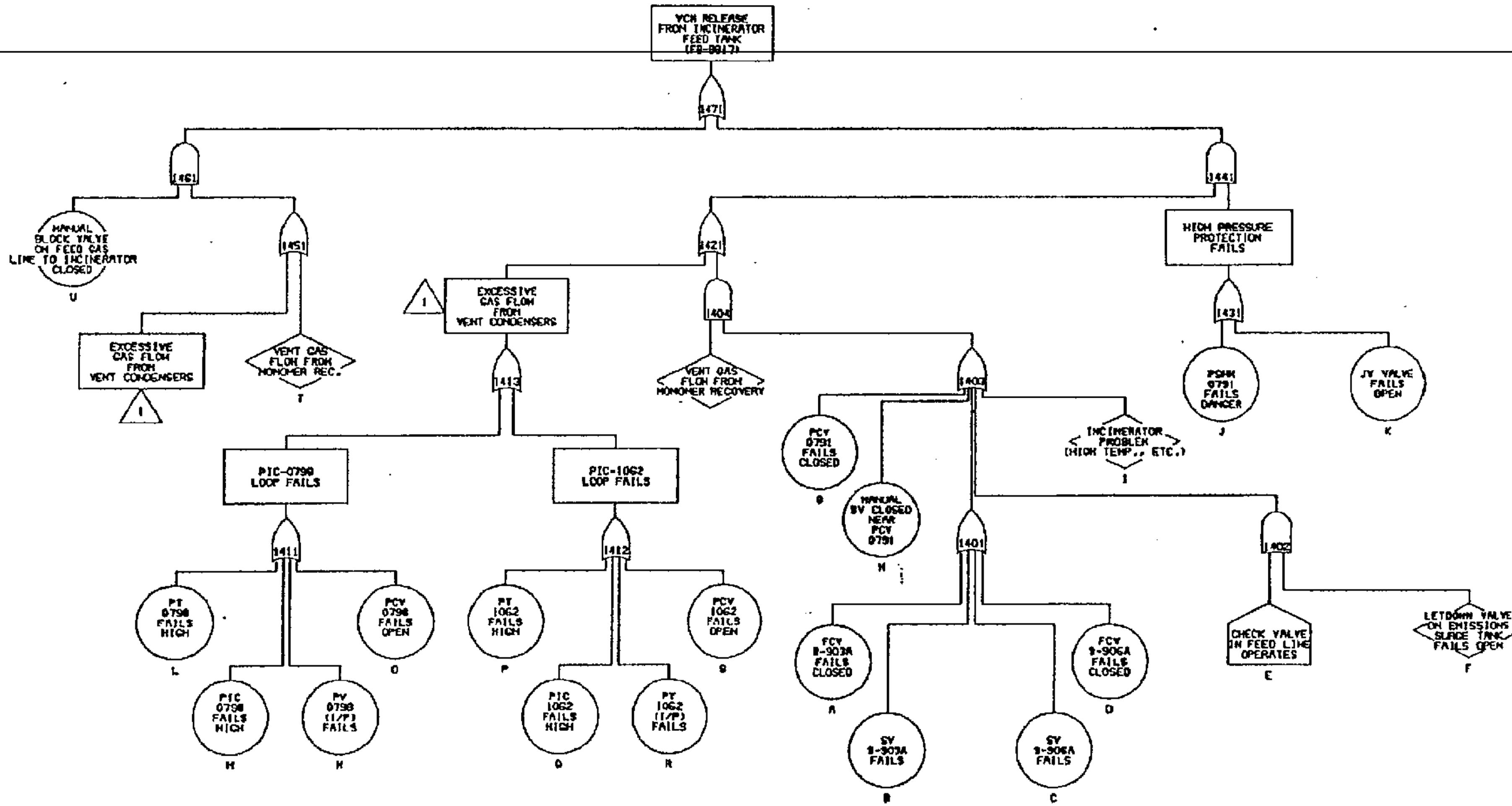


GAS SEPARATORS FC-8341/8342

NASH COMPRESSOR SEPARATOR FC-8312

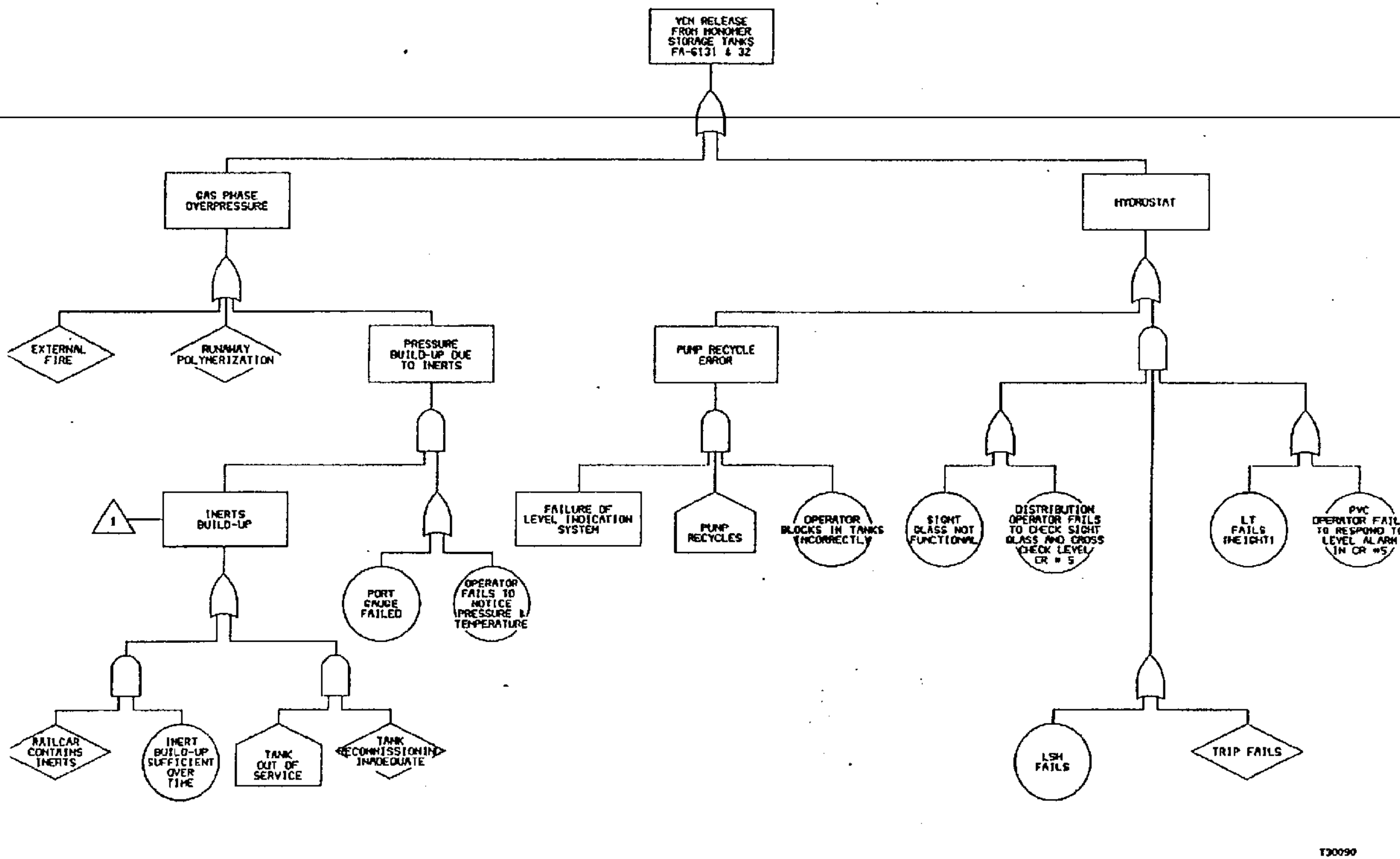


SHT. 1 OF 1
T30004



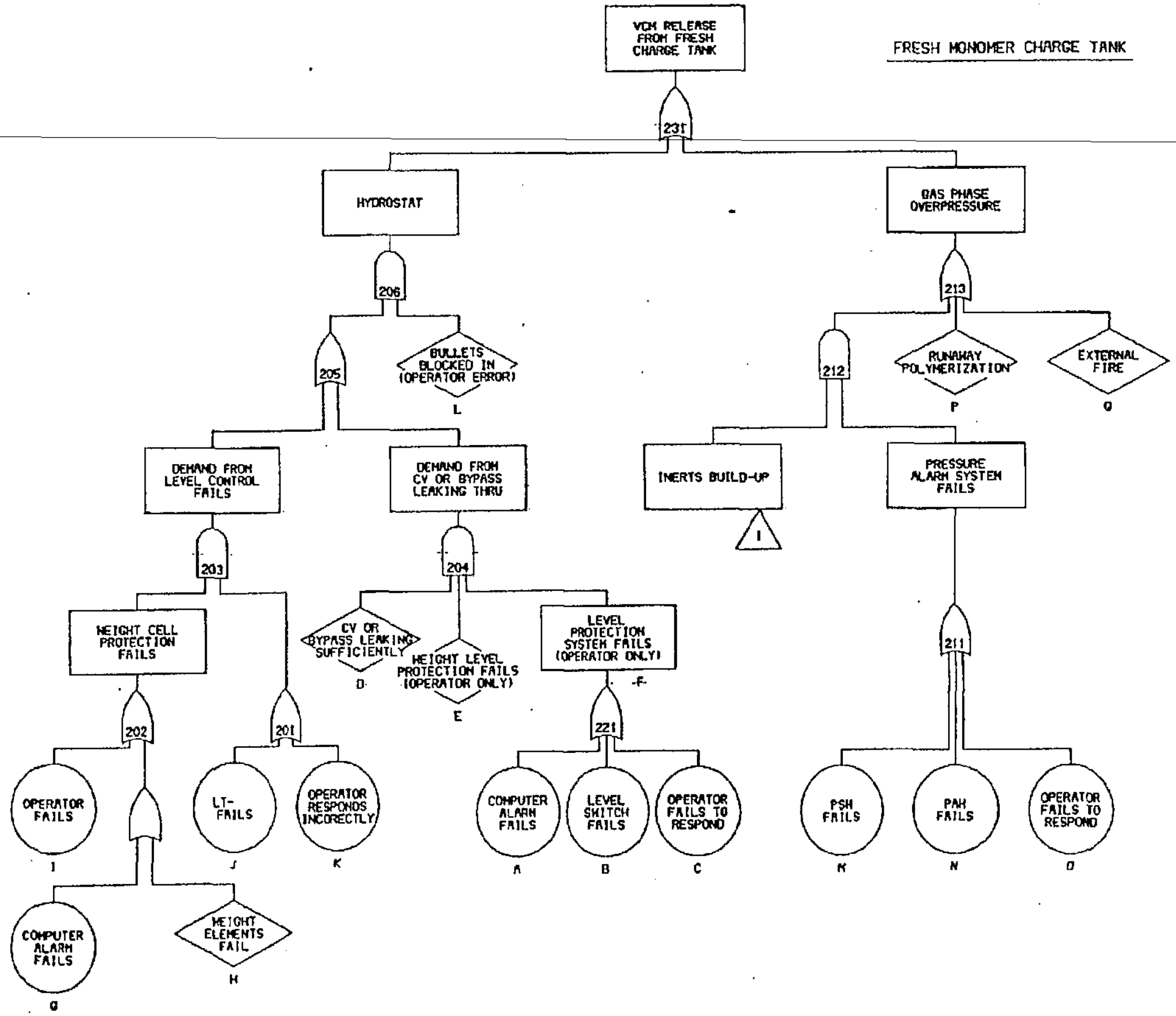
VCM RELEASE FROM INCINERATOR FEED TANK (FB-0017)
1471
1461
MANUAL BLOCK VALVE ON FEED GAS LINE TO INCINERATOR CLOSED
U
1451
EXCESSIVE GAS FLOW FROM VENT CONDENSERS
1
VENT GAS FLOW FROM MONOMER REC.
T
1441
1421
EXCESSIVE GAS FLOW FROM VENT CONDENSERS
1
1413
PIC-0798 LOOP FAILS
1411
PT 0798 FAILS HIGH
L
PIC 0798 FAILS HIGH
M
PV 0798 (I/P) FAILS
N
PCV 0798 FAILS OPEN
O
PIC-1062 LOOP FAILS
1412
PT 1062 FAILS HIGH
P
PIC 1062 FAILS HIGH
Q
PT 1062 (I/P) FAILS
R
PCV 1062 FAILS OPEN
S
1404
VENT GAS FLOW FROM MONOMER RECOVERY
1403
PCV 0791 FAILS CLOSED
G
MANUAL SV CLOSED NEAR PCV 0791
H
INCINERATOR PROBLEM (HIGH TEMP., ETC.)
I
1401
FCV 9-903A FAILS CLOSED
A
SV 9-903A FAILS
B
SV 9-906A FAILS
C
FCV 9-906A FAILS CLOSED
D
1402
CHECK VALVE IN FEED LINE OPERATES
E
LETDOWN VALVE ON EMISSIONS SURGE TANK FAILS OPEN
F
HIGH PRESSURE PROTECTION FAILS
1431
PSHH 0791 FAILS DANGER
J
JV VALVE FAILS OPEN
K

AP0003012 3

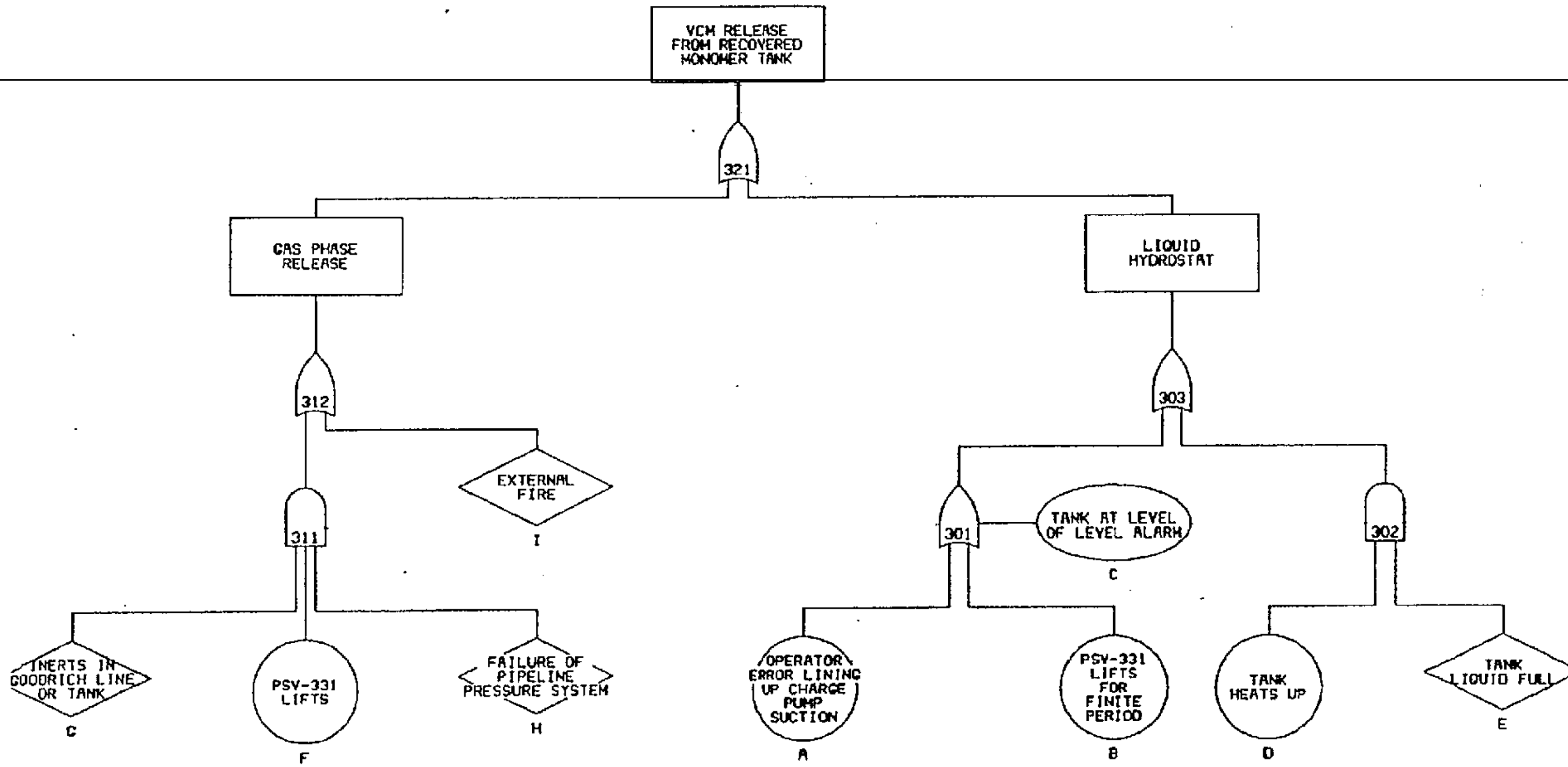

VCM RELEASE FROM MONOMER STORAGE TANKS FA-6131 & 32
GAS PHASE OVERPRESSURE
HYDROSTAT
EXTERNAL FIRE
RUNAWAY POLYMERIZATION
PRESSURE BUILD-UP DUE TO INERTS
PUMP RECYCLE ERROR
1
INERTS BUILD-UP
FAILURE OF LEVEL INDICATION SYSTEM
PUMP RECYCLES
OPERATOR BLOCKS IN TANKS INCORRECTLY
SIGHT GLASS NOT FUNCTIONAL
DISTRIBUTION OPERATOR FAILS TO CHECK SIGHT GLASS AND CROSS CHECK LEVEL CR # 5
LT FAILS (HEIGHT)
PVC OPERATOR FAILS TO RESPOND TO LEVEL ALARM IN CR #5
PORT GAUGE FAILED
OPERATOR FAILS TO NOTICE PRESSURE & TEMPERATURE
RAILCAR CONTAINS INERTS
INERT BUILD-UP SUFFICIENT OVER TIME
TANK OUT OF SERVICE
TANK RECOMMISSIONING INADEQUATE
LSH FAILS
TRIP FAILS
T30090

AP00030124

FRESH MONOMER CHARGE TANK

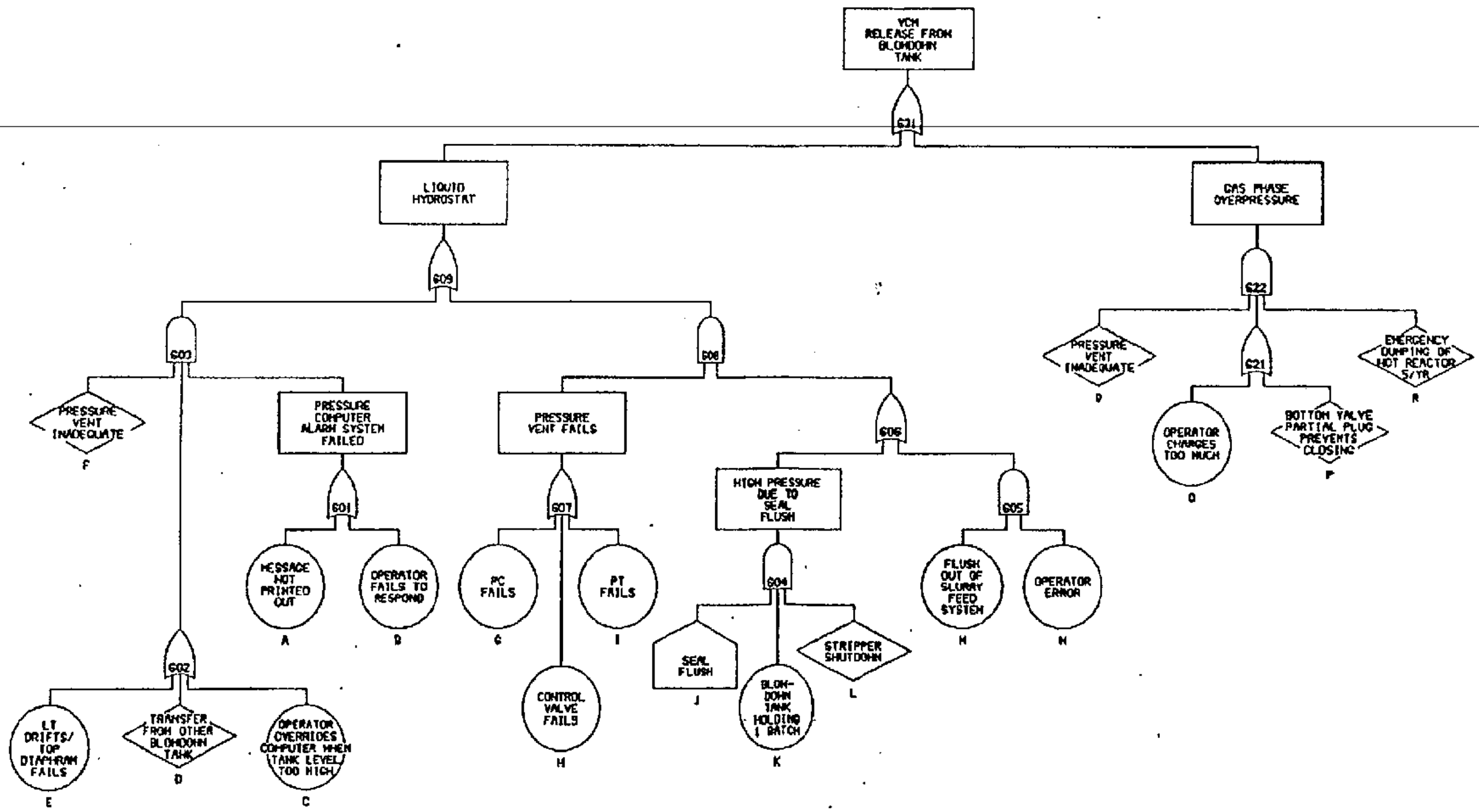


AP00030125


VCM RELEASE FROM RECOVERED MONOMER TANK
321
GAS PHASE RELEASE
LIQUID HYDROSTAT
312
303
EXTERNAL FIRE
I
311
301
TANK AT LEVEL OF LEVEL ALARM
C
302
INERTS IN GOODRICH LINE OR TANK
C
PSV-331 LIFTS
F
FAILURE OF PIPELINE PRESSURE SYSTEM
H
OPERATOR ERROR LINING UP CHARGE PUMP SUCTION
A
PSV-331 LIFTS FOR FINITE PERIOD
B
TANK HEATS UP
D
TANK LIQUID FULL
E

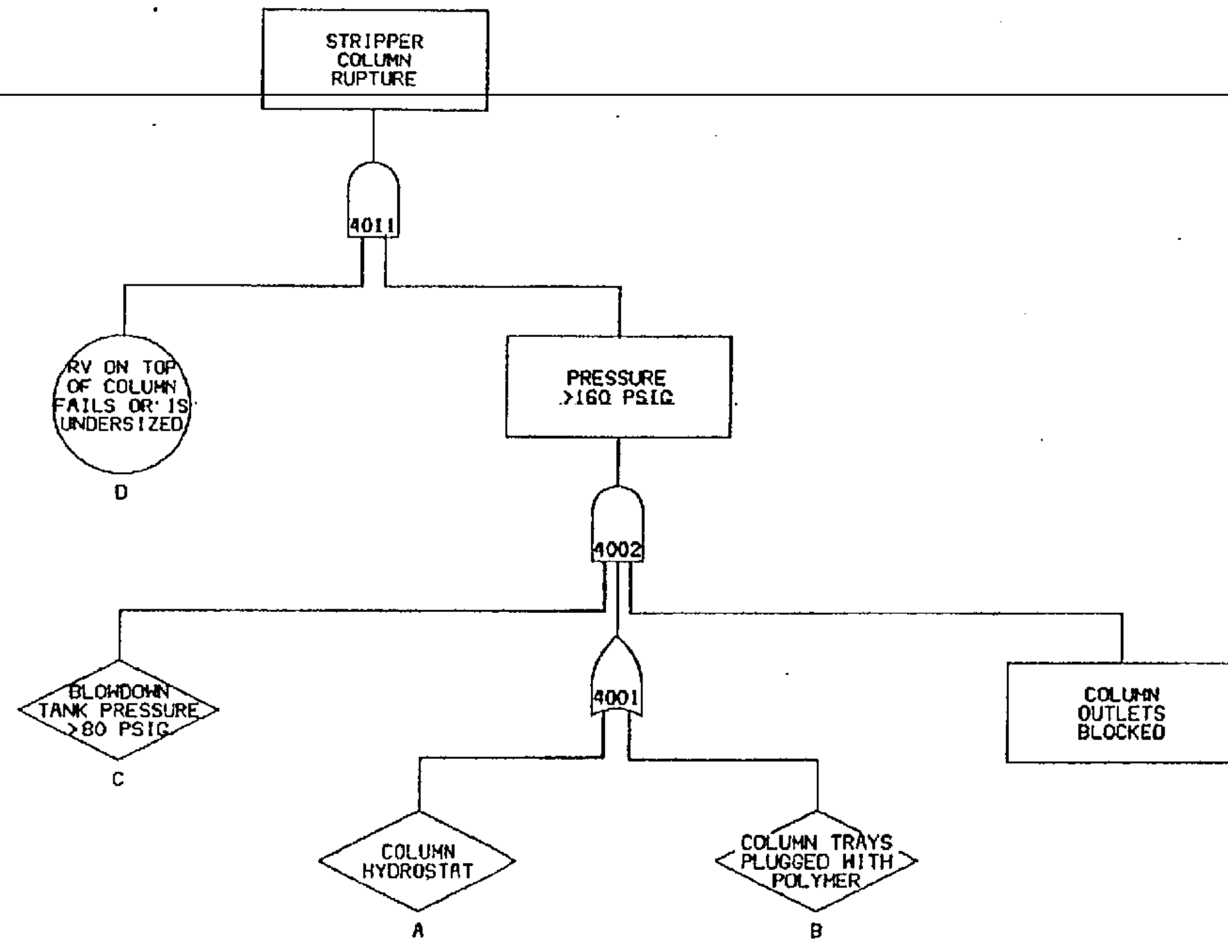
T30092

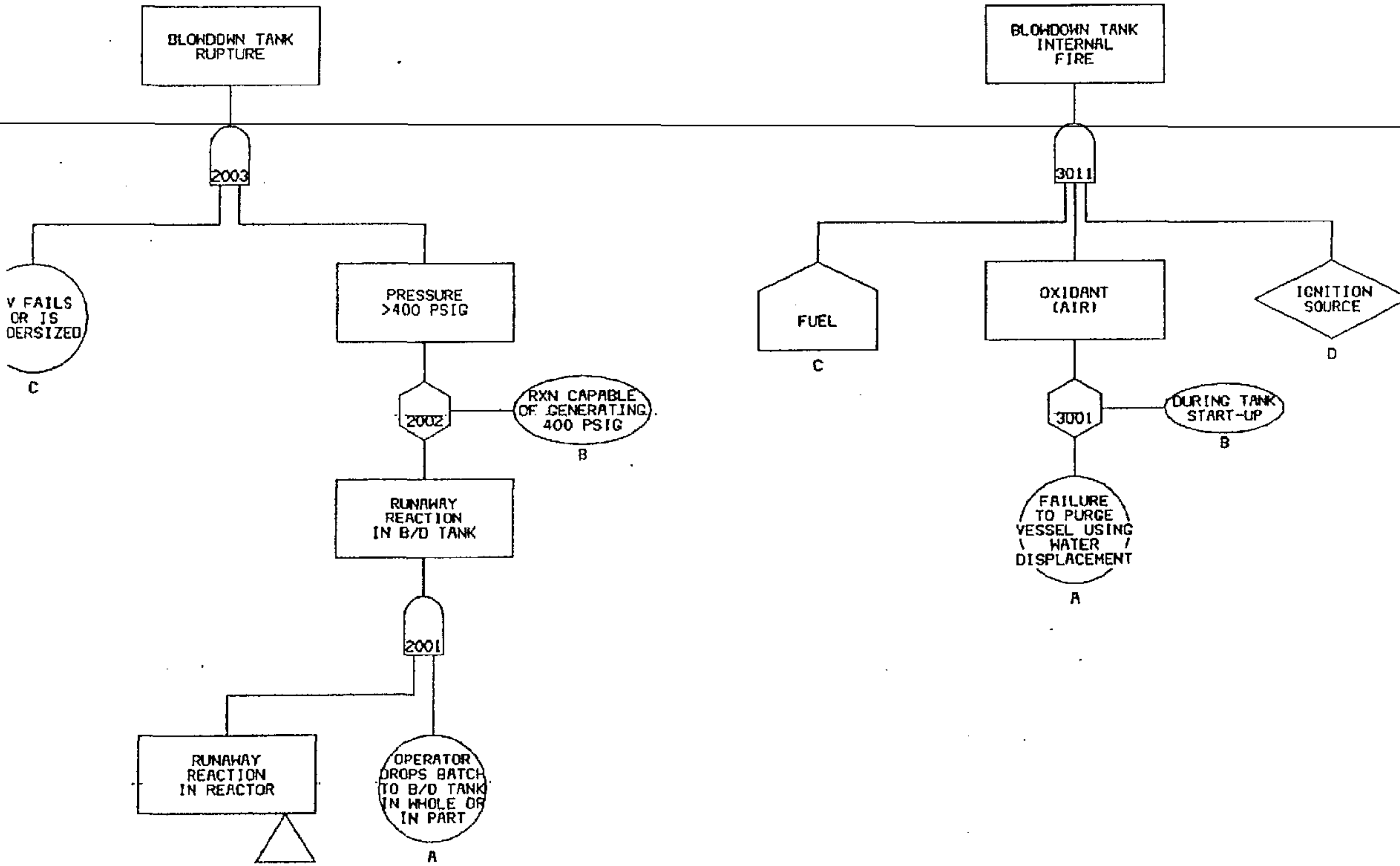
BLOWDOWN TANKS



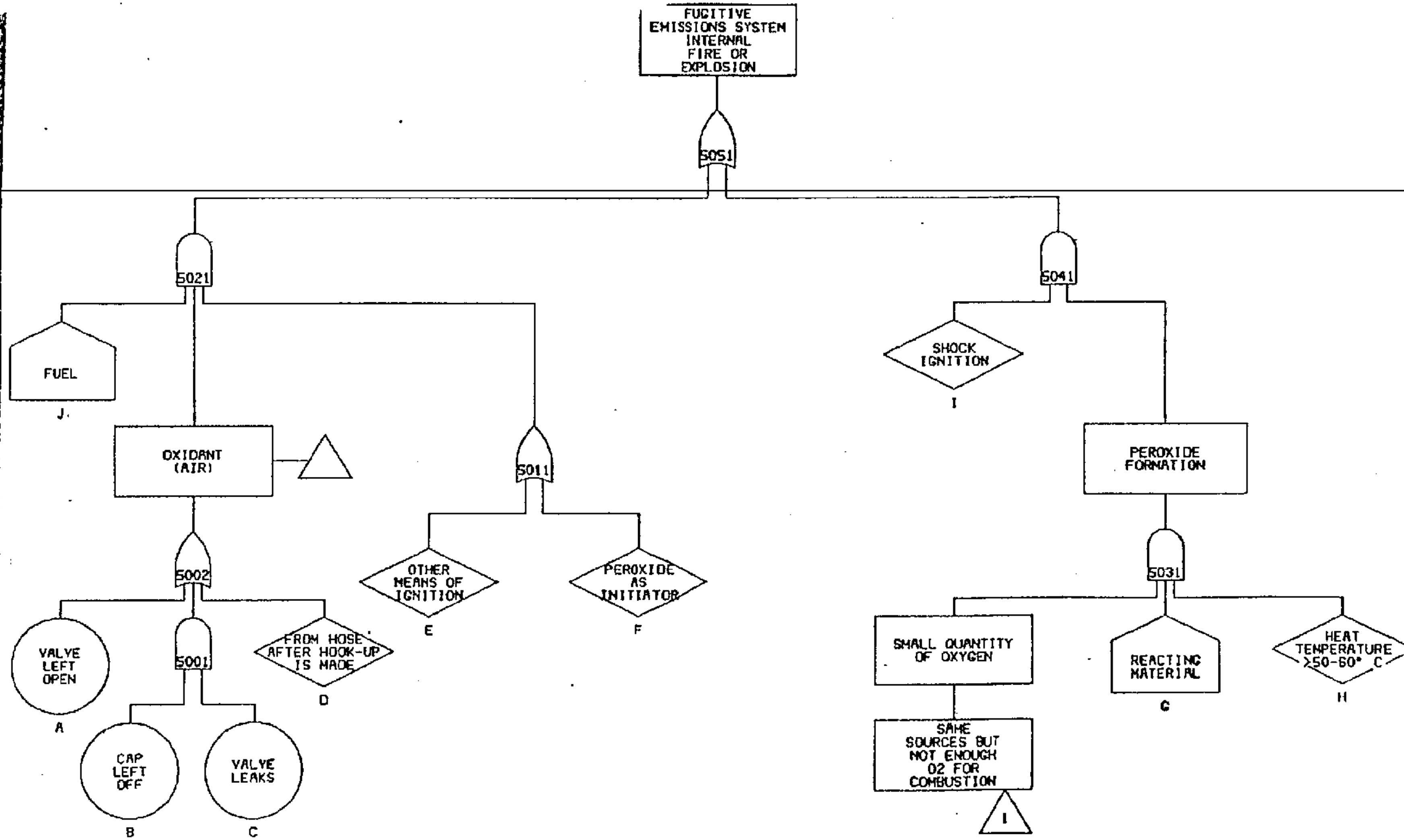
T30078

AP00030127


STRIPPER COLUMN RUPTURE
4011
RV ON TOP OF COLUMN FAILS OR IS UNDERSIZED
D
PRESSURE >160 PSIG
4002
BLOWDOWN TANK PRESSURE >80 PSIG
C
4001
COLUMN OUTLETS BLOCKED
COLUMN HYDROSTAT
A
COLUMN TRAYS PLUGGED WITH POLYMER
B



BLOWDOWN TANK RUPTURE
2003
V FAILS OR IS DERSIZED
C
PRESSURE >400 PSIG
2002
RXN CAPABLE OF GENERATING 400 PSIG
B
RUNAWAY REACTION IN B/D TANK
2001
RUNAWAY REACTION IN REACTOR
OPERATOR DROPS BATCH TO B/D TANK IN WHOLE OR IN PART
A
BLOWDOWN TANK INTERNAL FIRE
3011
FUEL
C
OXIDANT (AIR)
IGNITION SOURCE
D
3001
DURING TANK START-UP
B
FAILURE TO PURGE VESSEL USING WATER DISPLACEMENT
A



FUGITIVE EMISSIONS SYSTEM INTERNAL FIRE OR EXPLOSION
5051
5021
5041
FUEL
J
OXIDANT (AIR)
5011
SHOCK IGNITION
I
PEROXIDE FORMATION
5002
OTHER MEANS OF IGNITION
E
PEROXIDE AS INITIATOR
F
5031
VALVE LEFT OPEN
A
5001
FROM HOSE AFTER HOOK-UP IS MADE
D
SMALL QUANTITY OF OXYGEN
REACTING MATERIAL
G
HEAT TEMPERATURE >50-60° C
H
CAP LEFT OFF
B
VALVE LEAKS
C
SAME SOURCES BUT NOT ENOUGH 02 FOR COMBUSTION
I