Georgia Gulf

Georgia Gulf Chemicals and Vinyls, LLC
Aberdeen, Mississippi, USA
21 and 22 June 2001

Prepared by

Kevin Snowdon BEng, MSc, AMIChemE, MIOSH, MSFPE
Global Property and Casualty
Willis Limited

Contents

Introduction

This report is a description and risk assessment of the Georgia Gulf Chemicals and Vinyls PVC resin manufacturing and compounding plant located in Aberdeen, Mississippi, USA The report is intended to assist in the placement of material damage, machinery breakdown and business interruption insurances

This was our first survey to this facility since it was purchased by Georgia Gulf in November 1999 The survey was conducted over a two-day period from 21 to 22 June 2001 by Kevin Snowdon, Willis, London with the assistance of Richard Deaner, Marsh, Atlanta In the course of the survey discussions were held with senior representatives from all key management departments and a representative inspection of all important process areas was conducted The co-operation of all personnel met during the survey is very much appreciated with the main contacts including

Paul Kober	-	Plant Manager
Chris Markerson	-	Safety & Health Manager
Kelly Woods	-	Operations Engineer
Rory Sneed	-	Unit Manager, PVC Compounds
Dan Miller	-	Reliability Engineer

This report has been reviewed by Georgia Gulf and includes all their comments and corrections

Summary

The Aberdeen PVC resin production and compounding facility dates originally from the 1960's and was completely revamped with modern technology in the 1970's under the ownership of Conoco The ownership of the site transferred to the Vista Chemical Company and onto the Condea group (RWE) before Georgia Gulf finally purchased the facility in November 1999 along with a package of other olefins and vinyls facilities The PVC technology is common to the industry and well proven in all cases with the key facilities and production highlights summarized below

Unit	Nominal Capacity	Current Production	Year Comm.	Comments
VCM Rail Unloading	-	-	-	18 unloading spots 16 rail cars per day
VCM Storage sphere	2 5 MM lbs	70% level	1974	
PVC Resin Manufacturing ❑ West Module ❑ East Module	 590 MM lbs/yr 410 MM lbs/yr	650 MM lbs /yr Total	1973 onwards	Modules are basically independent units except for a common batch stripper in the West Module that could be replaced within four months
Drying ❑ Rotary (5) ❑ Fluid Bed Drier ❑ Cyclone Dryers (2)	 10,000 lbs/hr each 25,000 lbs/hr 30,000 lbs/hr each	65% 3 operate idle 2 operate	1973 onwards	
Plasticizer	20 MM lbs/yr	15 MM lbs/yr	1965	Batch esterification reaction
Compounding	125 MM lbs/yr	75%	1995	

The plant has a full demand of 1 billion lbs/yr of VCM that is supplied via rail from two Georgia Gulf VCM plants in Lake Charles, LA and partly from their Plaquemine, LA facility Internal Georgia Gulf VCM capacity can meet Aberdeen's full demand but due to the slow down in the economy, the plant has been operating at only around 65% capacity and so Georgia Gulf corporation is in VCM excess In addition, due to market over capacity VCM could be readily purchased to maintain full production if required

The Aberdeen process is arranged in discrete and generally independent units that allow a good level of production flexibility if any unit or item of equipment is lost In addition, if the compounding unit were lost spare capacity is available at other Georgia Gulf facilities to enable full production to be maintained

Aberdeen is located in the north east corner of the state of Mississippi, USA with the site located just south of this small town in a mixed rural and residential area External third-party exposures are therefore considered low The site is located 220 miles from the Gulf of Mexico coast and structures are designed to withstand 90 mph winds thereby the risk of hurricane damage is considered low Tornadoes do occur in the area and if struck the plant could suffer significant damage, however, no tornadoes have touched down within 10 miles of the site All other natural exposures are considered average

The site is **well laid out** with above average separation distances between the major units Spacing inside each unit reflects the age of the various designs but ranges from worse than average in the West Module to average spacing in the East Module The VCM storage and unloading areas are well separated and arranged with safety features meeting best industry standards e g gas detection, automatic deluge coverage, break away isolation valves and full ESD valves In general

engineering standards are to internationally recognized best industry practice e g ASME stamped pressure vessels, NFPA designed fire protection systems etc

Standards of **operation** are good based on an experienced workforce, detailed operating procedures and all expected safe operating practices The PVC process is controlled through the OSHA Process Safety Management regulations and **safety standards** are considered to meet the high standards required with good controls and procedures in place to control all hazardous operations and work These standards are evidenced in the OSHA recordable incident rate for the site which ranks in the nation's top quartile which has attracted numerous safety awards from external parties

Maintenance and **inspection** both typically follow good industry practice and cover all expected issues commensurate with the relatively non-complex equipment involved in the process One area of concern is the inspection approach taken on the VCM sphere which has not been internally inspected since it was installed in the 1970's Although this approach is accepted by the authority having jurisdiction, we recommend a review to ensure it is compatible with corporate philosophy

The site has a good coverage of fixed fire protection systems covering the majority of fire hazards in the process and associated facilities i e deluge systems in resin modules, sprinklers in compounding, plasticizer and warehousing buildings These systems are supplied by a number of firewater supplies including two fire pump stations, a combined firewater/process water system and back-up connections to the municipal city water system ensuring an adequate supply to all systems These automatic systems will be supplemented by a well trained **emergency response team** and the municipal fire department resulting in a good overall strategy for fire fighting

The insurance values and our estimated maximum loss scenarios are summarized in the table below

Values and Loss Estimates Summary				
Values (2000/2001) Property Damage	US$ 236 6 million			
Business Interruption ▪ PVC Resin ▪ PVC Compounding ▪ Plasticizer	US$ 85 6 million US$ 10 5 million US$ 3 0 million			
EML Scenario	**(EML amounts are in US$ million)**			
	BI Period (months)	**PD**	**BI**	**Total (PD+BI)**
Explosion – VCM release	18	113 2	102 3	**215 5**
Machinery Breakdown - generic	18			**10 0**

Overall, the Georgia Gulf Aberdeen facility can be ranked as an **above average** risk in accordance with our Chemical Risk Assessment Matrix

General Information

Company Background

The Aberdeen site began life as a family owned concern in the 1960's utilizing small reactor technology to produce PVC The facility was sold to the then Continental Oil Company (subsequently Conoco) who invested heavily in the site and introduced the world's first example of large reactor technology during the 1970's which has since become the standard throughout the PVC industry Dupont then purchased Conoco in 1981 and the site became a part of the Conoco Chemicals division of Dupont

The Conoco Chemicals Division went through a leveraged buy out in 1984 to form the new Vista Chemical Company Vista went public in 1987 and was eventually sold to RWE to become a part of their Condea group and hence the new divisional name of Condea Vista Georgia Gulf finally bought the Aberdeen site as a part of an olefins and vinyls package of facilities from Condea Vista in November 1999

The facility has been managed by a stable workforce which has moved as a part of the various changes in ownership of the site Today there are 188 personnel on the site including 126 hourly paid workers

Site Location

The site is located in the north east corner of the state of Mississippi, directly south of Aberdeen in the county of Monroe

Third Party Exposures

The facility is located in a mixed rural and residential area in which third-party exposures are considered light The nearest third parties are residential properties located approximately 0 25 miles to the north and east of the property Georgia Gulf continue to buy up land surrounding the site to ensure a safe buffer zone is maintained and only recently the site acquired additional farmland to the south of the site

The nearest industrial exposure to Georgia Gulf is the BASF super absorbent polymer plant which is located over 1 ½ miles away

Consideration of Major Perils

Fire and Explosion

The principal fire and explosion exposure is presented through the unloading, storage and processing of vinyl chloride monomer in the PVC resin manufacturing process VCM has a wide flammable range of 3 6 to 33% and a boiling point of 7°F VCM is stored and handled on site at up to 60 psig and ambient conditions, whereby if the material was allowed to leak to atmosphere a vapor cloud could be expected to be generated As such the storage and processing of VCM presents a exposure to spill and jet fires, vapor cloud explosions (VCE) and boiling liquid expanding vapour explosions (BLEVE)

All areas where VCM is handled are protected by a good standard of both process safety design features and fire protection systems For example, all VCM inlet and outlet lines to storage and process vessels are equipped with remotely operated, fail closed emergency shut down (ESD) valves In addition, all areas are protected by water spray or deluge systems arranged to be automatically actuated upon redundant heat and gas (40% LEL trip level) detection systems Together with all normally expected protection features such as fireproofing, emergency procedures and response capability, the fire and explosion potential of VCM is considered to be well controlled

Alcohols are used in much smaller quantities in the plasticizer manufacturing unit The alcohols have a relatively high flash point and primarily present a spill fire potential Protection features are commensurate and include process ESD valves and full sprinkler protection of all building areas handling alcohols The alcohol tank farm is reliant upon hydrant coverage only

The compounding units and associated warehousing present only a moderate fire hazard For example, PVC in pellet form is classified by NFPA as the lowest fire potential Group C plastic and only minor quantities of heating oil are used in the compounding process This moderate hazard is well addressed by sprinkler systems that are installed to protect all areas of the warehouse and compounding plant Although the design of the system is suggested to be verified, it can be expected that the system will provide a quick first response to any fire incident

PVC resin is not considered to pose a dust explosion hazard, thereby no special precautions are needed or installed in the PVC drying and storage facilities

Overall, the fire and explosion risk is minimized through a good provision of process safety features, fixed fire protection systems and manual fire fighting resources

Storm/Flood

This area of Mississippi experiences a warm climate governed by the Gulf Coast, with typically high temperatures and humidity experienced during the summer and freezing conditions occurring only rarely during the winter Freeze protection is provided for critical systems including fire protection systems

Rainfall is high and violent electric storms can bring heavy down pours of rain The storm water drainage for the site is designed for such conditions and no flooding due to water run-off has been experienced The site is situated ~3 miles from the Tombigbee-Tennessee water way which is formed from a series of dams and locks creating a commercial waterway from the Great Lakes down to the Gulf of Mexico The level of the waterway is controlled, although during extreme conditions it can flood It is reported that the plant is located at least 20 to 30 ft above the previous worst case flood level from the waterway and as such has no history of flood damage

The Gulf Coast is vulnerable to direct hurricane activity but Aberdeen is located over 220 miles inland which acts as a natural buffer zone helping to downgrade any such storms before they arrive over the site The wind resistance design for the plant was specified in compliance with Conoco's standards of the day and is specified for the process structures to be 90 mph This is considered adequate for the area and has ensured the plant has not suffered any significant windstorm damage over the past 30 years

This area of Mississippi is prone to tornado activity and is rated in accordance with the Munich Re World Map of Hazards as being exposed to 2 to 10 tornadoes per 10,000 km^2 per year No tornadoes have touched down within 10 miles of the plant and no damage has been experienced However, if the plant suffered a direct hit, significant damage could be expected The plant has detailed extreme weather procedures

Lightning does occur in this area although it is reported that the plant has never knowingly been struck All high structures have lightning conductors and all process structures and equipment are grounded

Earthquake

The site is located in an area of low seismic activity and according to the Munich Re's World Map of Natural Hazards is classified as a Zone 0 earthquake area This equates to a maximum earthquake intensity of 'V and below', as measured on the Modified Mercalli Scale (medium subsoil conditions) This intensity of earthquake has an exceedance probability of 10% in 50 years equivalent to a 475 year return period

Riots/Strikes/Malicious Damage

The work force is unionized although the last union strike was in 1974 Since then union relations have improved and there has been no history of malicious damage at the site It should be noted that the risk of strikes and malicious damage is present during contract negotiations, which will next take place in March 2002

A good level of security is in place for the facility including full perimeter fence, constantly attended gatehouse and card access controls The site is located in a mainly rural low risk area with no history of malicious damage and thereby the risk is considered low

Vehicle, Vessel and Aircraft Impact

All non-essential traffic is prevented from entering the site and the employee car park is located outside of the site's boundary fence Only authorized and essential traffic is allowed on site where there is a reasonable network of roads and a speed limit of 15 mph Access to process unit areas is strictly controlled by permit authorization Rail cars are used extensively but are limited to areas external to the main process units The rail cars are leased and Georgia Gulf employees are used to control all movements on the site One key issue is the storage of up to 50 VCM rail cars in the site's rail siding area to provide a buffer stock of VCM Although the overall exposure to vehicle impact is well controlled the high volume of VCM cars does increase the risk potential which is considered worse than average

The nearest public and military airports are located at Columbus approximately 30 miles and 20 miles respectively from the site The complex is not directly over flown by public flights but the USAF use the area for low flying The risk of aircraft impact is therefore considered slightly worse than average

Loss History

In April 1998, a catalyst freezer was destroyed by fire Inadequate cooling of the peroxide allowed the temperature to build steadily beyond the freezer ability Since then storage practices have been modified to prevent a reoccurrence The incident caused only limited property damage which was believed to be less than the deductible at the time

No property insurable losses have been sustained under Georgia Gulf

Risk Improvements

The following new recommendations were discussed briefly with senior management at the end of the survey The recommendations were all received positively

For information, the recommendations made by Zurich Services Corporation during previous surveys are noted in this report Only two recommendations remain outstanding which are planned to be completed during 2001

New Recommendations

01-01 Electrical Equipment Hazardous Area Integrity

The proper maintenance of rated electrical equipment and/or rated enclosures is required to prevent undue ignition sources We have two areas of concern that are recommended to be addressed as follows

(a) The Substation 7C manometer was reading 0 05 inches and a number of control panel manometers were observed to be reading zero

It is recommended that a formalized pressurized enclosure maintenance/checking routine is introduced to ensure all enclosures are adequately pressurized to at least 0 1 inch of water at all times The above noted examples should be addressed as a part of this initiative (REFERENCE NFPA 496 para 2-3 1)

(b) A number of examples of rated electrical equipment were observed where the integrity of the gas tight enclosure had been compromised because of cracked covers, inadequate sealing or broken fittings These problems were also observed on some emergency lighting systems as well

It is recommended that an electrical equipment inspection routine is introduced to check all rated equipment for defects Any defects noted should be repaired as soon as possible (REFERENCE NFPA 70)

01-02 West PVC Reactor Module

The process area associated with the fresh and recovered VCM vessels is relatively old and is beginning to need upgrading to ensure process safety standards are consistent with the remainder of the site In addition, this area should be recognized as one of the high hazard zones of the site with the potential to release a significant quantity of VCM into a vapor cloud As such we recommend the following issues are addressed

(a) The VCM charge pumps are located very close to the storage vessels and presents a possible exposing seal fire Although the storage tanks are water spray protected it is recommended that the water spray protection is extended to cover the seal area of the pumps to reduce the exposure hazard (Reference NFPA 15)

(b) The support legs of the three VCM tanks are mostly constructed of concrete However, the upper most portion of the legs are formed by non-fireproofed steel Although the vessels are water spray protected, coverage to the legs may be incomplete allowing the possibility of their failure during the very early stages of a spill fire leading to a possible escalation of the incident To apply consistent standards as installed on the East module we recommend fire proofing is extended to the vessel's exposed legs (Reference OSHA Regulation 1910 106 (b)(5)(ii) and API 2218)

(c) Insulation is installed to an inconsistent standard to VCM piping This has allowed sections of the pipe to be exposed to the atmosphere and the external paint protection layer to fade We recommend the exposed sections of pipe are cleaned and painted to protect against future external corrosion and pipe insulation standards are improved

01-03 East PVC Reactor Module

The fresh and recovered VCM tanks in the East Module are well arranged and protected by water spray protection systems The systems cover the external side walls of the vessels but not the area beneath the vessels Although some run down of firewater may be expected, NFPA 15 specifically recommends coverage is provided for the entire protected vessel surface area As such we recommend the water spray system is extended to cover the underside of the four vessels (Reference NFPA 15 para 4-1 4)

01-04 Plasticizer Unit

The Plasticizer unit comprises of four reactors which are initially filled with alcohol and phthalic anhydride before a liquid catalyst is added through a funnel and valve arrangement on top of the vessel We have a number of observations where the risk of electrostatic spark generation could create a possible hazard

- The alcohol is splash filled into the vessel since the inlet line does not extend to the bottom of the reactor vessels This type of filling may create electrostatic build-up and if combined with a flammable atmosphere inside the vessel could cerate an explosion hazard
- The catalyst is again splash filled into the vessel See above for same comments on possible electrostatic hazards In addition, the use of a simple open valve and funnel arrangement could lead to a flammable atmosphere being created around the open funnel where air is allowed to mix with the vessel vapor If the operator or the catalyst receptacle is not adequately protected against electrostatic build-up, a spark maybe created in this area leading to a possible explosion incident

These are only brief observations on the hazards of the reaction process which we feel justify the need for a full review and process hazard analysis (PHA) of the operation We therefore recommend a PHA is conducted on the plasticizer reaction process primarily to cover the electrostatic hazards associated with the unit but preferably to cover all aspects of the process

01-05 Alcohol Tank Farm

The grade level inside the alcohol tank farm has been previously concreted to improve the liquid tightness of the dike This has led to a number of pipes coming into close contact with the ground From our brief observations the area of ground contact appears to have increased the external corrosion rate of the pipe

We recommend the contact areas are inspected and measures are taken to reduce the risk of further corrosion in this area Common protection philosophies could include cathodic protection, external wrapping and/or raising the level of the pipe to avoid ground contact (Reference API 570 para 5 3 4)

01-06 Open Breather Vent Inspection Program

A full inspection and test program is conducted on pressure relief vent valves but no similar program is practiced on atmospheric breather vents Tanks with such vents rely upon the full open vent area to prevent an over or under pressurization due to filling or emptying operations

We recommend the common practice of including all such breather vents into the pressure relief valve inspection program

01-07 VCM Storage Sphere Inspection Program

We understand the VCM storage sphere has never been internally inspected since it was installed in the 1970's Although this approach has been accepted by the local authority having jurisdiction and is based on evidence from full internal inspections at VCM spheres at other Georgia Gulf facilities, it is somewhat inconsistent with the approach taken at other Georgia Gulf sites

We recommend a review is conducted to ensure that this approach is consistent with the Georgia Gulf corporate inspection philosophy In addition, the approach can be completely justified on the grounds of evidence of not only Georgia Gulf VCM sphere internal inspection results but those from the wider PVC/VCM industry

Zurich Services Corporation Outstanding Recommendations

The following recommendations are noted to be outstanding following their most recent survey to Aberdeen on 3 May 2001

00-07-01 Screwed Fittings in LPG Service

Two propane tanks on the east side of the facility supply back-up fuel to the boilers during periods of curtailment Of the two pumps associated with this system, one is equipped with screwed fittings on both the suction and discharge sides Some corrosion on the piping was evident

The chemical process industry has suffered several fire/explosion incidents in the recent past These incidents have been directly attributed to the failure of screwed fittings Typical degradation of the carbon steel combined with continuous vibration of a nearby pump has fatigued the steel to the point of failure

Status *The replacement parts are on site and will be installed before the end of 2001*

00-07-2 North Fire Water Pond

An initial observation of the north fire pump pond would indicate that continued, unchecked settling in this pond may eventually compromise this critical fire water supply As silt and other unwanted material continue to build up along the south edge, the fire pumps may become isolated from the majority of the water in the pond

Status: *The dredging process is being discussed with a local contractor to determine the most cost-effective manner The pond may only be dredged near the pump house, which will still satisfy this recommendation Completion is expected before the end of 2001*

Values and Estimated Maximum Losses

Property Replacement Values

The property insurable values for the site are reported as US$ 236,555,000 on a replacement basis The values were reported by the Georgia Gulf Insurance Department and quoted valid for the 2000/2001 insurance period This value was further broken down into the following areas

- PVC Unit – US$ 200,979,000
- PVC Compounding – US$ 27,852,000
- Plasticizer Unit – US$ 7,724,000

We have made the following estimates of a further breakdown of values but please note these values are for **indicative purposes only** and are only provided to aid in the generation of our Estimated Maximum Loss calculation

Insurance Value Breakdown Estimate

Area	Value (US$ million)	
East PVC Module		**65 0**
West PVC Module		**52 0**
❑ Reactors	44 0	
❑ Recovery Area	8 0	
Control Building		**6 0**
Dryers		**30 0**
❑ Cyclone dryers (2 off)	15 0	
❑ Fluidized bed dryer	5 0	
❑ Rotary dryers (5 off)	10 0	
Plasticizer Unit		**7 7**
❑ Process building	6 7	
❑ Storage facilities	1 0	
Compounding		**27 9**

Business Interruption Values

The annual gross earnings business interruption value for the site is reported as US$ 99,167,000 for the 2000/2001 insurance period The following breakdown of this value was provided and additional split between the East and West Modules was made by the Aberdeen Plant manager

- PVC Resin manufacture – US$ 85,635,000 total BI split as follows
  - West Module – 59% of PVC BI equivalent to
  - East Module - 41% of PVC BI equivalent to
- Compounding operation – US$ 10,532,000
- Plasticizer – US$ 3,000,000

Please note the plasticizer production unit is estimated to currently save 5 cents per lb of plasticizer produced over and above that which could be purchased in from external sources With the current production of 15 million lb/yr, this represents an extra expense value of US$ 750,000 per year if the unit were shut down

Business Interruption and Interdependency Discussion

Import Facilities

The main raw material for the site is vinyl chloride monomer (VCM) that is primarily supplied by other Georgia Gulf facilities in the group as summarized below

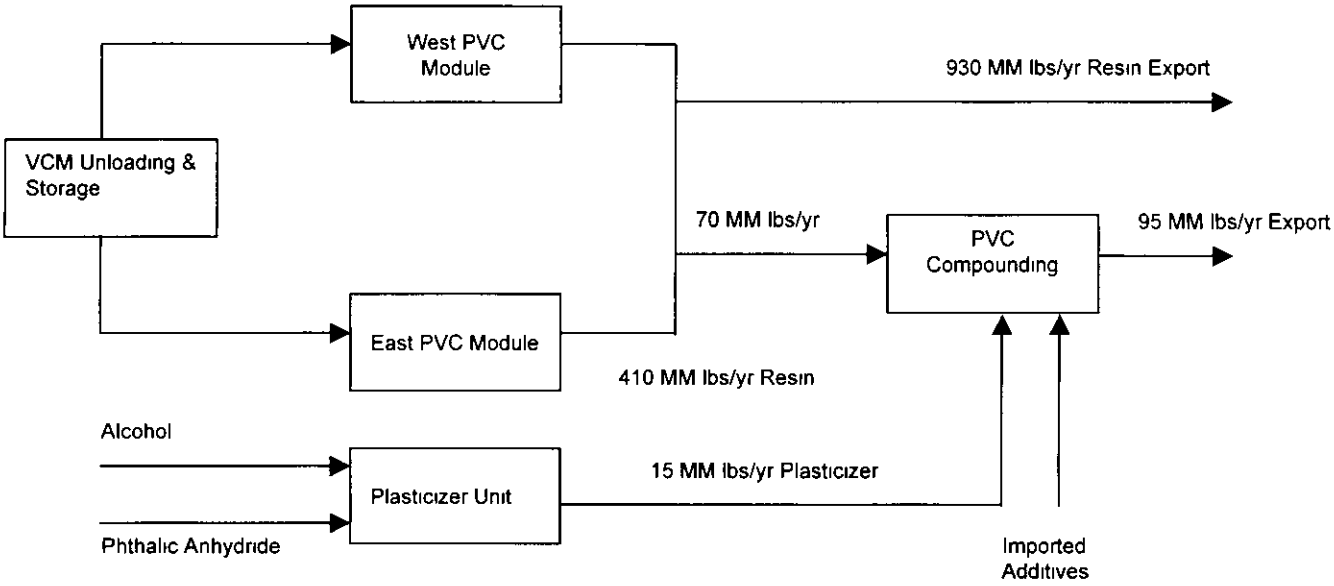
- Lake Charles – a fully owned Georgia Gulf facility located in West Lake near Lake Charles The facility was purchased from Condea Vista in 1999 and has a capacity of 950 million lbs/yr of VCM A full description of the plant is covered under a separate report
- PHH – a 50/50 joint venture company owned by Georgia Gulf and PGG The facility has a capacity of XX million lbs/yr of VCM and is located approximately one mile south of the Lake Charles facility
- Plaquemine – this is the largest Georgia Gulf facility that is also located in Louisiana The facility is a multi-unit complex with acetone/phenol, chlorine/caustic, PVC and VCM units The VCM unit has a capacity of 1,600 million lbs/yr which is primarily supplied to their on-site PVC unit but also supplies around 10% of the Aberdeen plant's demand Again, details of this facility are shown under a separate report

The total demand for the Aberdeen site is one billion lbs/yr when operating at full capacity, which together with the Oklahoma site can be fully met by the Lake Charles and PHH supplies However, due to the slow down in the US economy the plant has been operating over the past twelve months at around two thirds capacity with a reduced demand of around 650 million lbs/yr This has resulted in much more flexibility in the supply situation and enforcing some of the supply units to take extended shut down periods

In addition, if any supply problems were encountered at the Georgia Gulf VCM units it is reported that due to market over capacity, replacement VCM supplies could be readily purchased from the spot market to maintain full production at Aberdeen

Product Flow Scheme

The interdependencies between the various units are illustrated below with throughputs noted at full capacity



Although the flow scheme shows a number of interdependencies, the arrangement of the plant allows for a high degree of flexibility between the units and gives the option that all internal intermediate supplies could be replaced by external supplies The highlights of the BI features include the following

- **PVC Modules** – the two modules are almost entirely independent except for a common batch stripper located in the West module If the West module suffered significant damage including the common equipment, both modules would initially shut down for approximately four months until emergency arrangements could be made to re-start the East Module In the reverse situation, the East Module could be lost without affecting the West Module
- **VCM unloading and storage** – the unloading facility has 18 spots arranged along two rail lines Loss of any particular spot will not affect production although a loss of a line will lead to a partial production loss In addition, the site has only one VCM storage vessel which if down will lead to a full shut down of PVC manufacturing operations until alternative arrangements could be made for unloading cars directly into the process
- **Plasticizer Unit** – if the unit were shut down for whatever reason, replacement plasticizer could be readily sourced externally to allow full production in the compounding unit The replacement plasticizer could be sourced at an extra cost of 5 cents per lb above internal production costs
- **Compounding Unit** – it is reported that there is sufficient spare capacity within the Georgia Gulf group to allow the full compound production from Aberdeen to be transferred to other compounding facilities This transfer will require increased cost of working due to additional weekend work at the other units and additional transportation costs However, this is estimated to be significantly less than the financial loss if the unit were to shut down completely

Utilities Bottlenecks

The plant is equipped with a reasonable level of installed redundancy within the main services and utilities However, a loss of the largest steam boiler, any transformer, air compressor or process water pump will have an immediate but partial affect on the plant's total output In all cases the utility equipment is standard in design and relatively small allowing hired units to brought in quickly to replace the lost capacity The heavily industrialized Gulf area is relatively close which gives many options for hiring in equipment as necessary

Estimated Maximum Loss Calculations

Our Estimated Maximum Loss calculations consider the largest loss that could result from a single incident in the plant It assumes that the initial incident is so large that the active protection systems are rendered inoperative and only the passive protection facilities, such as spacing and fireproofing are effective

Various scenarios have been considered but only those which are considered to represent the maximum loss potential are reported here Blast damage caused by vapour cloud explosions has been evaluated using the Swiss Re's ExTool TNT equivalent based model and follows the damage criteria as detailed below An efficiency factor of 4% is used for straight chain hydrocarbons and is adjusted in the range ± 2% in the presence of other factors specific to the site, such as degree of confinement and presence of high energy ignition sources Following current Swiss Re practice the base efficiency factor is increased for more reactive materials such as ethylene and propylene (6%)

Overpressure (psi)	Average Damage (%)
>5	80
2-5	40
1-2	5

In addition, vapour cloud explosion EML's detailed in this report also consider the damage caused by secondary effects, such as pool fires, initiated by the explosion

Details of the largest light hydrocarbon circuits are given below Inventories, pressures and temperatures are at operating conditions

Description	Material	Total Normal Inventory (USgallons)	Pressure (psig)	Temp (°F)
West Module				
▪ DM013 Fresh VCM Receiver	VCM	5,100	50 to 80	70
East Module				
▪ DM999 Fresh VCM Receiver	VCM	7,850	50 to 80	70

Please note the business interruption values used in our EML's may not fully reflect the slow down in production at the site Although this is the best information available at the present time, it can be estimated that its use will generate conservative EML values

Vapor Cloud Explosion EML – West Module Fresh VCM Vessel

The largest 'in-process' hold-up of VCM is stored in the fresh VCM tanks associated with the East and West Modules The worst case explosion estimate is assumed to originate from an instantaneous and total release from the West VCM vessel which will result in a vapor cloud Although the release is smaller than that from the East Module, when the cloud is allowed to drift it creates more damage due to the concentration of equipment in the area and the loss of the West Module has a greater business interruption impact on the site

An efficiency factor of 8% has been assumed in the TNT equivalency model to account for the relatively high reactivity of VCM and the average congestion within the process unit

The West Module is considered to be virtually destroyed (100%) and anticipated to take 18 months to rebuild In addition, the East Module is also considered to have suffered significant damage (40%) resulting in an 8-month repair period

The compounding plant output could be relatively easily replaced by spare capacity at other Georgia Gulf facilities Extra costs will be required to continue this mitigation process which we assume to be 2 cents per lb The overall loss estimate can then be shown to be

Explosion EML Calculation	**(US$ Million)**
Material Damage	107 8
Debris clearance and miscellaneous costs @ 2 5%	2 7
Inflation costs	2 7
Total Material Damage Loss	**113 2**
Business Interruption	
❑ West Module US$ 50 5 million x 100% x 18/12 months	75 8
❑ East Module US$ 35 0 million x 100% x 8/12 months	23 3
❑ Compounding extra expense 5 cents x 95 million lbs x 8/12 months	3 2
Total Business Interruption Loss	**102 3**
Combined Total (MD + BI) Loss	**215 5**

Machinery Breakdown EML

The PVC process is not typified by large process equipment and it is difficult to envisage a machinery breakdown incident causing significant business interruption For indication purposes only we have estimated that a machinery breakdown EML will not exceed **US$ 10 million**

Site Facilities

Raw Material Supplies

The primary raw material for the PVC process is vinyl chloride monomer At full capacity the PVC resin plant consumes around three million lbs/day of VCM which has reduce over the past twelve months to two million lbs/day due to the reduction in output (see Business Interruption section) VCM is supplied via rail car from two Georgia Gulf plants in Lake Charles and unloaded at the plant's 18 spot unloading system (see Storage and Loading) The VCM is stored in a single storage sphere with a capacity of 2 5 million lbs together with additional storage within rail cars of up to 10 million lbs in the yard area

The VCM is pumped via delivery pumps located at the sphere over to the fresh VCM charge tanks in the two PVC reactor modules

PVC Resin Manufacturing

An overview of the PVC resin manufacturing process is shown in Appendix 1 All PVC produced is suspension grade

The PVC plant is divided between two banks of PVC reactors known as the East and West Modules The West Module is the older of the two and dates from 1973 when the first large reactor technology to be operated was installed here The remaining total of 12 reactors were installed over the next ten years with the key facilities summarized as following

- West Module – 5 reactors and one stripping line
  - One fresh VCM charge tank and two recovered VCM tanks
  - 4 x 18,000 gal reactors
  - 1 x 35,000 gal reactors
  - Stripping line with four compressors and two vacuum pumps

- East Module – 7 reactors and two stripping lines
  - Two fresh VCM charge tanks and two recovered VCM tanks
  - 4 x 23,000 gal reactors
  - 3 x 35,000 gal reactors
  - Two stripping lines with five compressors and three vacuum pumps

Both sets of reactors are located in open concrete and/or fireproofed steel structures in dedicated areas separated by ~240 ft

The PVC process in both modules follows the conventional batch reaction route which begins at the fresh VCM charge storage tanks associated with both modules The vessels, which represent the largest hold-up of process VCM, are protected with automatic water spray systems, fireproofed supports and all inlet and outlet lines are equipped with remotely operated isolation valves The older West module fresh and recovered VCM vessels are more congested and have a number of negative features primarily related to their age which are recommended to be addressed (see Recommendation 01 02) All VCM pumps are installed with double mechanical seals

To produce suspension grade PVC the reactors are first charged with water followed by up to 11,500 gal of VCM using dual flow meters If the previous batch was stripped in the vessel, a vacuum is pulled on the vessel before charging to prevent the possibility of a build-up of a flammable mixture The catalyst is added last before the exothermic polymerization reaction is first initiated by steam heating and then controlled in the range of 125 to 150°F by reflux control The batch reaction is continually stirred and takes between 3 to 5 hours at pressures ranging from 110 to 150 psig depending on the grade of product The reactors have extensive protection systems and interlocks which can be summarized as follows

- Automatic activation of 'kill dose' on high temperature or pressure interlocks System is nitrogen pressure actuated from cylinders that are checked daily
- Emergency cooling water can be operated from the control room to control runaway reaction Water supply can be continued during power outage from dedicated emergency generator and diesel engine driven firewater pumps
- Loss of agitator alarm detected by amperage
- Gas detection throughout outside storage and process areas arranged to actuate local deluge fire protection systems
- Burst discs and pressure relief valves in series with interstitial leak detection gauges Valves are vented to atmosphere at high level
- Automatic waterspray protection over entire reactor and stripping process area

The off-gases from the process are compressed and condensed The liquefied VCM is collected in recovered VCM buffer tanks situated adjacent to the fresh VCM charge tanks associated with each module These tanks have a similar level of protection as the fresh VCM tanks (see earlier)

The completed reactor batches can either be stripped inside the reactor or dumped to dump tanks which act as buffer storage for the continuos downstream stripping process The stripping process is arranged into three independent process lines and comprises of feed tanks and stripping columns where VCM is stripped using steam before it is removed under vacuum, recovered and returned to the recovered VCM tanks

The process downstream of the strippers is considered low hazard since all VCM has been removed from the PVC slurry and there is no PVC dust explosion hazard Downstream of the strippers the slurry is collected in blend tanks before being dried by three methods (see Appendix 2 for process details)

- Rotary drying – five rotary dryers each rated for 7 to 10,000 lbs/hr with only a maximum of three currently on duty The dryers use direct natural gas heating
- Fluid Bed Dryer – one 25,000 lb/hr drier again using direct natural gas heating together with two blowers (150 and 50HP)
- Cyclone dryers – two 30,000 lb/hr dryers equipped with forced and induced fans (150 and 700 HP) which have stored spare motors

The natural gas fired equipment is equipped with a good standard of combustion controls including automatic purge sequence, flame detection, and double block and bleed isolation valves

The finished product passes to 21 silos which range in size from 150,000 to 700,000 lbs 19 of the silos are elevated to allow rail loading

Compounding

The compounding unit at Aberdeen has a capacity of 125 million lbs/yr but currently only operates at 75% throughput The facility is arranged as is common for such facilities with an process overview shown in Appendix 2 Compounding is divided into two lines that are located in a five storey building where the resin is first transferred in at the top level and through gravity transfer is finally removed as finished product from the ground level

The two sets of kneaders (600 HP) and extruders (150 HP) have spare motors and shaft elements and are reported to be highly reliable All areas within the enclosed concrete structure building is sprinkler protected

Plasticizer

The plasticizer unit is a small 20 million lbs/yr reactor facility installed in 1965 The unit produces plasticizer for use in the compounding units at both Aberdeen and Prairie

The process is relatively simple and involves the batch reaction of phthalic anhydride and alcohol in the presence of an initiating catalyst (see Appendix 3) The subsequent esterification reaction is endothermic and needs to be steam heated to 300°F at 5 psig over four hours to complete the reaction

Storage and Loading

All VCM is received via rail car which is a service contracted to the Kansas City Southern Railway Company Although details of the routing were not available, it is believed there are numerous routes for the transfer from the Lake Charles area to Aberdeen and no significant delivery problems have occurred except for derailments that have not caused production disruptions in the past

The VCM is unloaded at the site's 18 point unloading station located in the extreme west area of the site The facility top unloads around 16 rail cars per day representing a supply of two million lbs/day The VCM is directed to a 2 5 million lb pressurized sphere that is normally operated at 70% full level The unloading facility has numerous safety features and procedures that can be summarized as follows

- Water spray system covers the entire length of the loading spots which is automatically actuated via a pneumatic frangible bulb system and gas detectors that cover the area
- High level monitors located around the periphery of the loading station designed to provide additional exposure cooling
- Rail cars separated, double choked and grounded before unloading can begin
- Georgia Gulf employees connect up flexible hoses to trucks and monitor process by CCTV continuously
- Armored hoses are equipped with break away automatic isolation valves
- Vapor inlet and outlet lines equipped with emergency isolation valves (fail closed) actuated by burn through tubing or manual buttons located locally and in the control room

Overall, the VCM rail unloading facility is considered to be protected and operated to best industry practice

Alcohol for the plasticizer process is also unloaded via rail cars at the much slower throughput of around two cars per week The cars are unloaded at a dedicated loading spot located near to the alcohol's tank farm on the eastern side of the process area The loading spot has no fixed protection systems but a similar level of procedures and safety precautions are taken in this area as noted for the VCM facility Any spills will be directed to a catch basin from where they are directed to an oil separation pit

Phthalic anhydride is imported by rail car in solid form and must first be steam heated before transfer into a 170,000 lbs tank No additional special precautions are taken due to the low hazardous nature of the material

The VCM sphere is the largest storage vessel on site with a total capacity of 2 5 million lbs The vessel is well detached to the west of the process area and is well protected by the following safety features

- A 'top hat' or water weir firewater protection system to provide external cooling to the vessel surface which is automatically actuated via a pneumatic frangible bulb system and gas detectors The gas detectors are arranged to alarm at 20% LEL and actuate the system at 40% LEL
- Fixed monitors located around the diked area designed to provide additional exposure cooling
- Full containment, concrete dike wall that is graded away from the vessel to allow pooling beyond the shadow of the vessel
- Independent level detection devices arranged to trip the loading process and isolate all ESD valves upon a high/high alarm
- ESD valves on all inlet and outlet lines controlled through the trip system or manually from the control room
- Double pressure relief valves with burst discs and isolation valves installed beneath Isolation valves are locked and allow the valves to be tested when required

The remaining storage facilities on site are primarily associated with the PVC resin and compounded finished resin products A small tank farm associated with the alcohol raw material and plasticizer products is located in the eastern part of the site The tanks are diked in common groups and equipped with open breather vents No additional protection is afforded to the tanks although the hazards are considered only moderate

Export from the site is primarily by rail and truck All PVC resin is exported by rail directly from elevated silos The compounded product is exported 40% in bulk by rail or truck and 60% in 1600 lb tote bins The tote bins are stored in the warehouse attached to the compounding plant in an area covering approximately 50,000 ft^2 The boxes are stored to approximately 12 ft high and the area is sprinkler protected, although the design of the system could not be confirmed

There are written procedures and guidelines covering all loading and unloading operations and overall, loading operations appear to be well controlled

Layout and Construction

The site is located north of Aberdeen in a mixed rural/residential area with only light surrounding exposures (see Third-party Exposures section)

The site is essentially level, covering an area of 288 acres of which 50 acres is covered by process operations A plot plan of the site is shown in Appendix 7 The remainder of the site is open land surrounding the site ensuring there is an adequate buffer zone between all adjoining residential properties of at least 0 25 miles

The VCM storage sphere and rail unloading area are situated in the far western area of the site with the following separation distances

- West Module – 360 ft
- East Module – 600 ft
- Compounding Building – 700 ft
- North Fire Pump House – 160 ft
- South Fire Pump House – 1000 ft

As can be seen the process areas are relatively well detached Although the North Pump House is located within recommended distances (IRI guidance), there is a second South Pump House located out of risk range

The PVC resin modules are located in dedicated process structures separated by 240 ft The individual modules reflect spacing philosophies consistent with the practices followed at the time of construction, hence the west module is considered worse than average congestion and the east module average Construction typically consists of conventional open steel or concrete structures which in the case of the steel have been fireproofed to up to a height of around 20 ft or to the highest structural support Compressors and pumps are installed at grade which in some cases is in close proximity to process vessels (see Recommendation 01 02 (a))

The compounding plant is housed in a five story steel structure building with concrete block walls and pour in place concrete floors The building is detached by 720 ft from the PVC modules

The main PVC and VCM unloading control building is located 160 ft west of the west module and is of non-combustible construction that is designed to be blast resistant (adequacy confirmed by OSHA review) The building is additionally pressurized via elevated air intakes and equipped with gas detectors and a low pressurization alarm The building is divided into three fire zones each protected by smoke detectors arranged to actuate dedicated Halon systems

The Compounding control room is located on the ground floor of the compounding building with windows over looking the extrusion operation Since the building is fully sprinkler protected the arrangement is considered commensurate with the hazards presented

The boiler house and utility areas are arranged in a dedicated zone along the extreme east of the site The boiler house is a non-combustible building housing all four boilers Further to the east are three propane pressurized storage bullets (two in operation) which supply back-up gas to the boilers in cases where the natural gas supply is lost The vessels are well detached from any adjoining hazards, are directed away from the process area and are protected by an automatic water spray system One propane pump is installed with screwed fittings which is planned to be replaced with welded fittings in the near future (see previous Zurich Services Corporation Recommendation 00-07-1)

The majority of the facility was constructed under the guidance of Conoco in line with their strict standards and engineering guidance Internationally recognized standards have been used for the specification of equipment including ASME (all pressure vessels are code stamped), NFPA and others as relevant Although the majority of equipment was observed to be in good operational condition there were some areas where insulation practice was inconsistent and the coating and painting of piping needed attention (see Recommendation 01 02)

Overall, the layout of the site is considered better than average The spacing between the plants is good in relation to the hazards presented, although there are some areas of worse than average congestion Construction standards are considered to represent good industry practice

Utilities

The plant has two **electrical** overhead feeders supplied by the Tennessee Valley Authority from the national grid system Each line has a capacity of 15 MW which can nominally meet the plant's 15 2 MW demand The supply has proved to be highly reliable with only two outages reported in the last 20 years

The supply is received at 13 2 kV which is directly distributed to the various site substations via a branched network (see Appendix 4) Only the main PVC substation is supplied via a double connection providing a higher degree of reliability Power is distributed via armored cables in cable trays

Power is transformed to either 4 14 kV or 480 V in various transformers associated with each substation The transformers range in size from 1,500 up to 5,000 kVA and are generally not installed with redundant spare capacity It can be noted that none of the units are considered unique and replacement units could be hired in within days if required

The DCS and plant instrumentation systems are on UPS systems In addition, an emergency generator is available for critical safety users i e cooling water pumps on the PVC resin reactors, and all ESD isolation valves are arranged to fail closed on loss of air The plant has detailed procedures in cases of loss of power

Steam is generated in three 150 psi gas fired boilers rated as follows

Steam Boilers

Boiler No	Capacity (lbs/hr)	Manufacturer	Year of Construction
2	35,000	Springfield	1964
3	50,000	Cleaver Brooks	1969
4	80 000	Nebraska	1994

Total demand for the site ranges from 65,000 to 110,000 lbs/hr which is typically met by operating No 4 boiler and one other If boiler No 4 were lost the site have an idle boiler which could be brought into service within two months following repairs if required In the meantime, packaged boilers could be readily hired in to make-up steam demand

Process water is supplied from two on-site wells rated at 2,000 gpm each The aquifer supply drawn upon is reported to be reliable and high in iron content As such the water is treated in a treatment plant which then delivers water to the process system and a 110,000 gal gravity tank via two 1,500 gpm at 84 psi pumps This system is also used as a combined process and firewater system in the older parts of the site For example the compounding plant and associated warehouses are supplied firewater from this system although a cross connection is available to the pumped firewater system (see Plant Protection Facilities for further details)

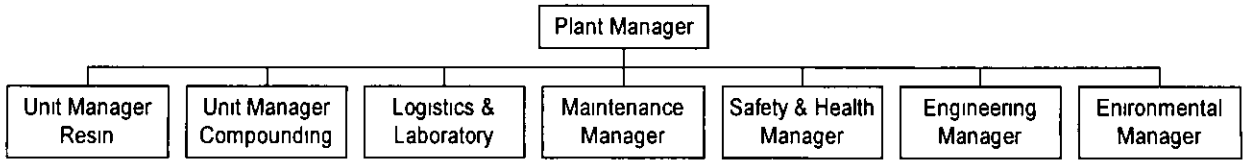
Process cooling is provided by cooling towers

Instrument and plant air is provided by six compressors The two systems are normally independent but are equipped with a normally closed cross connection If any machine was lost the cross connection could maintain partial production before a hired unit could be quickly installed to maintain full demand

The steam boilers and PVC resin dryers use **natural gas** The supply is reported to be reliable but interruptions can occur and as such two propane storage vessels are installed to provide back-up when required The propane supply is only adequate to maintain the steam boilers and enable the plant to achieve a safe shut down Extended loss of natural gas will have a significant impact on production

Management

The site employs 183 personnel split between 58 salaried and 125 hourly paid personnel The management of the site is a typical flat structure and is illustrated below



Operations

The Resin Unit is manned by 47 personnel with a further 29 in the Compounding Unit The operations team operate on a 12 hour rotating shift system comprising of four shifts each with a shift supervisor and eight operators Fifth supervisors are assigned to both the Resin and Compounding units who act as fill-in for the on-shift supervisors and to lead the operator training initiatives A permit supervisor is attached to the Resin Unit and both units are also assigned a Plant Engineer to oversee process and reliability improvements etc

Personnel turnover is low and therefore experience levels are generally high across all key positions

A good standard of **operating procedures** is available both on a computer networked system and on hard copies within control rooms The procedures cover normal operations, abnormal conditions, start-up and normal and emergency shut down The procedures are well formatted and include for a general discussion section plus a review of safety considerations around each type of task Professional technical writers together with operator input were used in the development of the procedures which are reviewed and revalidated every two years

The plant operates a **work permit** system to cover all 'safe' work, hot work, excavation and confined space The permit is a single form with specific sections for each of the different types of hazardous work and associated lists of the precaution checks needed Two copies of the forms are used (one displayed at the work place and one in the control room) which are authorized by the Unit Manager, the ERT standby and the Safety Department Permits are limited to a 12 hour period which must be reauthorized if extended to 24 hours or before any shift change All aspects of the work and precautions to be taken are formalized in procedures and at the end of the permitted work the permit must be returned to the control room and the final status of the job noted Although no formal handover signatures are required the permits appeared to be closed out adequately in practice

Isolation certificates are used in conjunction with the permit system to ensure equipment is adequately isolated prior to any work commencing Some equipment have 'pre-defined' isolation procedures while others are generated on a 'as required' basis The operations department first apply a unit lock to the isolation points before each person working on the job applies their own personal locks The unit lock is always the last to be removed and there are strict procedures for the forced removal of a lock Isolations typically involve double block and bleed arrangements and locked electrical breakers

In summary, a good level of experienced manpower is available supplemented by a good standard of operating and safety procedures Overall operations is considered to rate **above average**

Maintenance

The maintenance department numbers around 35 persons for mainstream maintenance with a number of specialist contractors used for low level work e g insulating and painting, and for project work The in-house resources are headed by a Maintenance Manager with two craft supervisors who oversee 19 mechanical and seven E&I technicians plus one planner, one utility operations supervisor and three maintenance engineers The mechanical integrity inspector also reports to the Maintenance Manager and whose work is discussed in more detail in the Inspection section of this report

Maintenance scheduling and the site's work order system are controlled on a centralized **Advantis XA** (formerly known as Marcam) computer system which replaced the previous SAP system The system is based on Georgia Gulf's corporate PSM approach to maintenance and now includes for all equipment on site The system controls all scheduling and is also used to track and analyze key maintenance indicators including mean time between failure

The site's **maintenance strategy** is focused on **condition monitoring** supplemented by routine planned and turnaround maintenance Turnarounds are conducted each year alternately between the East and West Modules This allows the reactors to be internally inspected every two years in accordance with the state regulations

The PVC and compounding process does not involve extreme service conditions or particularly large equipment and therefore the maintenance history is relatively good with, for example, mean time between failure rates for all rotating objects reported as 69 months and for pumps as 42 months It can be noted that all pumps in VCM service are equipped with **tandem seals**

The maintenance engineers focus on **reliability improvements** and oversee the **condition monitoring program** for each of the main areas Typical routines include monthly manual vibration readings on all large rotating equipment The critical equipment, including the process air compressors, are equipped with continuous vibration monitoring systems Weekly lube oil rounds are also conducted together with quarterly lube oil samples from compressors and gearboxes that are sent for analysis to external laboratory

Parts of the unit date from the 1960's and in some areas the external condition of the insulation and pipe work is showing unsatisfactory condition This is limited to a few specific areas and we have recommend that the fresh and recovered VCM storage area in the West Module is addressed to improve overall external conditions

The site is equipped with a **workshop** where the majority of pumps and compressors can be re-built to supplement the two yearly overhaul by vendors If required extensive engineering resources are also available in nearby Louisiana and Texas which can be utilized for major repairs

All pressure vessels on site are built to **ASME codes** and are code stamped As such any repairs are only conducted in accordance with the ASME standard by local workshops that have both 'U' and 'R' stamps Georgia Gulf employ ASME coded welders

A good level of planned maintenance is conducted on all **electrical equipment** including

- Annual **transformer oil analysis** by specialist laboratory including all expected checks
- Annual **thermographic monitoring** of all electrical equipment from HV down to LV using video imaging equipment
- **Circuit breaker** preventative maintenance including two yearly protective relay trip tests
- **Battery systems** are inspected monthly and functionally tested annually
- The **emergency generator** is tested weekly and functionally tested during the two yearly shut down
- Two yearly continuity check on grounding systems

Although a good system of electrical maintenance is in place we further recommend a regular inspection of electrical equipment rated for use in hazardous atmospheres and of pressurization systems in electrical substations and control panels (see Recommendation 01 01)

Instrumentation is included in the PM program Emergency shutdown systems are tested every two years at turnarounds although the critical systems protecting the VCM sphere are tested annually The ESD systems are functionally tested across the full loop from detection device through to the final actuating device

In summary, maintenance is considered to be adequately resourced and covers all expected areas The mainly good condition of equipment observed during the site tour provides further evidence that maintenance on the site is considered to be conducted to an **above average** standard

Inspection

Mechanical integrity is managed by a single mechanical inspector who reports directly to the Maintenance Manager The inspector is certified as a National Board inspector and has various licenses including API 510, 653 and 570 Qualifications in the use of non destruction testing techniques is reported to be level II in accordance with the Condea Vista internal training and certification system Although not confirmed, these certifications are considered to be equivalent to ASNT qualifications and cover dye penetrant, UT, radiography and visual

Inspection work is manually **scheduled** and manual records are maintained of the inspection data The data was recently inspected in detail by Zurich Services Corporation and reported to be maintained in good order Detailed inspection data for all vessels and pipes is available dating back to the 1970's which is used to manually calculate remaining life and retirement dates based upon API guidance It is reported that all inspection work is up to date without any significant back log

Pressure vessel inspections are conducted every two years during the turnarounds The inspections use internal visual and dye penetrant inspection techniques as applicable The resin reactors are inspected every year and specifically include for chloride stress corrosion monitoring and UT for thickness trending The only exception to this routine is the VCM storage sphere which has not been inspected internally since it was installed In lieu of internal inspections the vessel is fully inspected externally using UT on a 10 yearly frequency together with quarterly inspection of associated piping systems In addition, the site have received state approval for the current approach by providing evidence from internal inspections of vessels in service at both Oklahoma and Plaquemine plants throughout the 1990's All internal inspections reportedly have shown no signs of corrosion and have proven that the vessel is in an extremely clean service Although, we recognize these efforts to justify the lack of internal inspection we recommend the policy is reviewed to ensure the most stringent inspection codes are complied with (see Recommendation 01 07)

Pipe line inspections are conducted every two years Records of pipelines include for isometrics for each line with identified thickness check points and related readings The data is handled in a similar fashion as described above and is used to predict remaining life etc Corrosion under insulation (CUI) is an area of special concern and is addressed by using insulation port holes Some areas of excessive CUI were observed in the West module and are recommended to be addressed (see Recommendation 01 02) Flexible pipes are pressure tested annually

Atmospheric storage tanks are inspected in accordance with API 653 More specifically the tanks are externally inspected using UT annually and internally inspected every 10 years

Pressure relief valves are tested every five years except for the steam boiler valves which are tested annually in accordance with state requirements The majority of critical process PRV's are protected from process conditions by burst discs that are monitored to check if they pass The burst discs are rated for a six year life span but are changed out every 30 months The valves are overhauled by an approved workshop that holds a current 'VR' stamp in accordance with ASME All PRV's are reported to be included within the testing program but no open breather vents are included which we recommend are addressed to ensure all pressure relieving systems are confirmed to be in good working order (see Recommendation 01 06)

All **lifting equipment** is inspected in line with OSHA requirements and is tagged and stored in a central store room

In summary, the inspection function is headed by an experienced individual that performs the majority of expected inspections in line with good industry practice Of concern are the lack of internal inspections of the VCM sphere that is recommended to be reviewed and thereby overall, we consider the department to rate **average**

Fire, Safety and Security

Fire

The fire response strategy for the site is to primarily rely upon an immediate response to a fire incident from automatic water based fire protection systems that are installed to cover the majority of process and related fire hazard areas This initial response will be supplemented by the incipient response from operators followed by a manual response from the on-site fire team with further back-up resources available from the local professional fire department All operators receive annual incipient fire training

The site's **fire team** comprises of 24 volunteers covering all shifts, although not evenly, plus six support staff The fire team are all equipped with pagers which ensures a 75% turnout within 20 minutes any time of the day or night followed by a full turnout within one hour The fire team are trained in accordance with OSHA requirements and are rated as an interior structural fire brigade The training program includes quarterly in-house sessions comprising of class room and field based training (4 to 8 hours) plus one week per year at either Texas A&M or Mississippi Fire Academy professional fire schools Drills are planned to be held quarterly although it is recognized that these were not conducted in 2000 and so a new commitment to the drills has been made for 2001, which we fully endorse

The team is equipped with only basic **fire fighting equipment** which is considered adequate to supplement the extensive array of fixed protection equipment on the site For example, the team have standard bunker gear, air packs, portable monitors and a trailer containing rescue equipment

A **pre-emergency plan** has been developed for the site that covers most expected scenarios including fire, explosion, gas releases, bomb threat and extreme weather conditions The plan further details the emergency organization and responsibilities assigned to each role In any given incident the Plant Manager is designated as the Incident Controller and the Safety Manager as the Fire Chief The incident is controlled by the Incident Controller from the incident control room specifically set-up in the main office building Here the room is nearby to process and engineering information and is equipped with all expected communications equipment The media control centre is located on a nearby hotel

Although there are no mutual aid organizations in the area, the plant can call upon the municipal **Aberdeen Fire Department** The department is a full-time professional department providing a 5 minute response to the site with three trucks with foam capability The department has conducted familiarization tours in the past but, in a similar fashion as the on-site drills, a new commitment to make these tours a regular occurrence has been made

All fire fighting equipment is regularly **inspected and tested** in accordance with NFPA 25 guidance including the following routines All equipment observed during this survey appeared in good and readied condition

- Fire pumps are tested weekly, and flow tested and serviced annually
- Portable extinguishers are inspected monthly and serviced annually
- Deluge and sprinkler systems are tripped quarterly
- Hydrants, monitors and post indicator valves are put through annual preventative maintenance routines
- Annual service contracts on automatic fire detection systems and Halon system protecting the main control room

In summary, the site's reliance on a good level of installed protection systems backed up by a well trained on-site fire team is considered a **good** fire control strategy for the hazards presented

Safety

The Safety & Health Manager heads up the Safety Department with the aid of an Industrial Hygiene Technician/Safety Coordinator Safety is considered a line management responsibility with ultimate responsibility resting with the plant Manager Detailed safety policies and procedures have been developed based on original Conoco and Condea Vista procedures that have been updated to reflect the Georgia Gulf corporate approach The procedures cover all expected areas and are regularly reviewed and updated (see Appendix 5 for index of procedures)

A formalized procedure is used to **investigate all incidents** including near-misses The corporate standard technique for root cause analysis, Apollo, is currently being rolled out and together with the common computerized incident reporting system will aid in sharing lessons learnt with the remainder of the group

The site is currently reporting an OSHA **total recordable incident rate** (TRIR) of 0 9 which is a top quartile performance as compared to similar US chemical manufacturing companies, where the average rate is around 2 3 and the upper quartile rate is 1 4 In recognition of this record, the site was awarded three gold awards from the National Petroleum Refiners Association awards in 2000

Contractors are carefully scrutinized before being hired to ensure they have adequate safety polices and procedures, a good safety record and adequate insurance coverage's in place Each contractor on arrival at the site receives general and specific hazard orientation as required The orientation is assessed and backed-up with the issuance of a pocket safety handbook to all contractors Throughout major contracts, regular safety meetings and training sessions are held to ensure safety standards are maintained

Formalized procedures are in place to control all **modifications** unless they are classed as a 'replacement in kind' The system is paper based and ensures all projects and modifications are safety and pre-start-up reviewed before commissioning The level of the safety review depends on the complexity of the change and ranges from a full Hazop study to a check list type review Any change requires at least three approval signatures and includes provision to ensure all documentation updates and operator training requirements are tracked

Two **process hazard evaluations** (PHA) reviews have been completed on all process units The first series of PHA's were based on a full Hazop review which were recently revalidated on a second review of all the units

The site is subjected to a corporate PSM **audit** every three years with all actions tracked and actioned A safety observation program is in-place although only informal plant audits are conducted with little visibility by senior management

Overall, the safety function is rated **above average**, which is verified by the good safety record of the site

Security

The site is guarded by a contract guard posted 24 hours per day, seven days per week at the gate house The site is fully fenced and illuminated at night and due to the semi-rural location has not experienced any significant breaches of security All personnel enter using a card access system and only essential vehicles are allowed on site Overall, the site has an **above average** level of physical and active security systems

Plant Protection Facilities

The site is protected by extensive fire protection system that covers the majority of fire hazards in the process areas and associated facilities The system is based on two firewater pump houses taking suction from independent firewater ponds, a combined process water and firewater system supplying the older and less hazardous areas, numerous fixed fire protection installations and an emergency response team The fire fighting strategy of the site is to rely primarily on the immediate automatic response of fixed protection systems followed by the back-up of the emergency response team and external services These systems are more fully described in the following sections

Firewater Supplies

The site firewater supplies are provided by two sources (see Appendix 6 for system layout)

- **Dedicated Firewater Supply** – this supply comprises of two fire pump stations, the north and south stations, each containing four and two diesel engines driven firewater pumps respectively All pumps are vertical turbine type pumps rated for 2,000 gpm at 104 psi giving a total available capacity of 12,000 gpm Both pump stations take suction from approximately 2 5 million gal ponds giving at least five hours duration of supply from each station A recommendation to dredge the North pond is planned to be completed during 2001 (see Zurich Services Corp recommendation 00-07-02)

  The pumps are all UL/FM listed and are arranged to automatically start upon a drop in pressure within the firewater main The main is pressurized to 120 psi by two jockey pumps, one located in each station

  Firewater from the stations supplies all fire protection systems in the PVC Resin process areas The water is distributed to these areas via a looped underground cast iron/steel main equipped with a good provision of divisional valves A hydraulic study on the system in 1995 and 1998 concluded that the system was adequate to meet the worst case demand which was identified as the VCM tank unloading station with a total demand of 12,127 gpm (see Fixed Fire Protection Systems section for further details)

- **Combined Process/Firewater Supply** – this lower pressure system supplies firewater to the warehouse, compounding and office buildings on the site The supply originates from two well pumps (2,500 gpm each) which supply a water treatment plant From here two 1,500 gpm at 84 psi electric pumps supply the process/firewater main system and a 110,000 gal gravity tank On loss of power the gravity tank would continue to provide firewater to the fire protection systems until the cross connection from the pumped firewater system (see above) could be manually opened

  The system also has two normally closed connections available to the city water mains The 8 and 12 inch connections could provide a 60 psi supply, although details of flows were not made available

  The combined process/firewater system mains are a looped system of 8 to 10 inch underground mains covering the northern section of the site The provision of divisional valves is not as extensive as the pumped system

Both systems supply a total of 13 hydrants and 24 monitors positioned throughout the site providing a reasonable standard of coverage with the best coverage installed to protect the highest hazard areas i e VCM storage and unloading area

Fixed Fire Protection Systems

Extensive water spray protection is installed to protect all process and storage areas handling flammable materials except for the relatively small alcohols tank farm All systems are automatically actuated and designed to be in compliance with NFPA 15 with application densities ranging from 0 25 to 0 35 gpm/ft^2 Equipment all appeared to be UL listed or FM type which together with the good testing and maintenance regime should ensure a high degree of reliability for the systems The principal fixed protection systems comprise of the following with further details listed in Appendix 7 and shown in Appendix 6

- West and East Resin Modules – coverage to all reactors, fresh and recovered VCM vessels and stripping vessels Systems are actuated by gas detection (20% alarm/40% actuation) and frangible bulb system Some improvements in coverage are recommended for the West and East Module around the fresh and recovered VCM vessels
- VCM rail loading spots – automatic system (gas detection and frangible bulb) covering the entire length of the two rail lines unloading areas
- VCM sphere – water weir system actuated automatically by gas detection and frangible bulb system installed at the base of sphere
- Propane Storage tanks – full water spray coverage
- Warehouse and Compounding – full coverage sprinkler system with an unknown design supplied by the combined firewater/process water system It is suggested to review the design to ensure it complies with the latest NFPA standards
- Plasticizer Process Building - full coverage sprinkler system supplied by the combined firewater/process water system
- Workshop – full coverage sprinkler system supplied by the combined firewater/process water system

The protection systems supplied by the pumped firewater system have recently been hydraulically reviewed to confirm the adequacy of the firewater supply The worst case demand was determined as a full scale incident affecting the VCM storage sphere and loading rack, as follows

Worst Case Pumped Firewater Demand

Area	Required Flow (gpm)
Rail Unloading Rack	4,100
Second Rail Unloading rack	447
VCM Sphere	3,000
VCM vessels	2 000
Monitors	2,580
Total Demand	**12,127**

As can be seen the demand can be met if all six pumps operate However, it should be noted that if an explosion incident affected the VCM sphere some damage may be expected to the north pump house and associated firewater pumps Following such incidents, some protection systems will also be expected to be damaged and fire control will come to rely on manual fighting efforts with water being manually drafted from the firewater ponds

For comparison purposes, the firewater demands for the East and West Modules were calculated as 6,888 and 7,992 gpm respectively

Mobile Equipment

The on-site fire response team is rated as an interior structural fire brigade but has only limited mobile equipment as summarized below

- 2 x Apollo monitors – 500 gpm
- 2 x Ozzie monitors on trailers – 325 gpm
- Full bunker gear and air packs
- Rescue trailer equipped with confined space equipment
- HAZMAT rescue equipment
- 500 gals of foam concentrate in 5 gal pales

The mobile equipment can be used in addition to fixed equipment (see previous section) and incipient equipment i e 23 hose boxes located throughout the site which are equipped with 1 ½ and 2 ½ inch hose and associated equipment, monitors, hydrants and an adequate provision of hand-held/wheeled extinguishers

Gaseous Fire Extinguishing Systems

The main process Control Room and Laboratory Store Room are protected by automatic Halon total flood systems actuated by smoke detection systems

Gas Detection and Alarm Systems

Flammable **gas detectors** are positioned around all areas where VCM is handled including the VCM rail unloading facility, the VCM sphere, the Resin reactor modules and the stripping facilities The detectors are arranged to alarm at 20% LEL and actuate the fire protection systems in the areas noted at 40% LEL

Smoke detection systems are installed in the control room and the warehouse building The detectors in the control room are arranged to activate the Halon protection system Smoke detectors are not installed within electrical substations

All fire alarms are relayed via local **alarm panels** to the main control room In addition, any incident can be notified to the control room operators via a dedicated emergency telephone number from any telephone on site Upon receipt of an alarm the operator can activate the sitewide alarm which has recently been reviewed to ensure a clear audible alarm is received in all parts of the site The alarm is tested weekly

In summary, the site has an extensive array of fixed fire protection systems designed to cover the majority of high hazard fire areas These fixed systems can be supplemented by a manual emergency response team and overall the fire protection facilities for the complex are considered to rate **above average**

Appendices

1. PVC Process Overview
2 PVC Dryers
3. Compounding Process
4. Plasticizer Process
5. Electrical Distribution System
6 Safety procedures Index
7. Firewater System Layout
8. List of Fire protection Equipment