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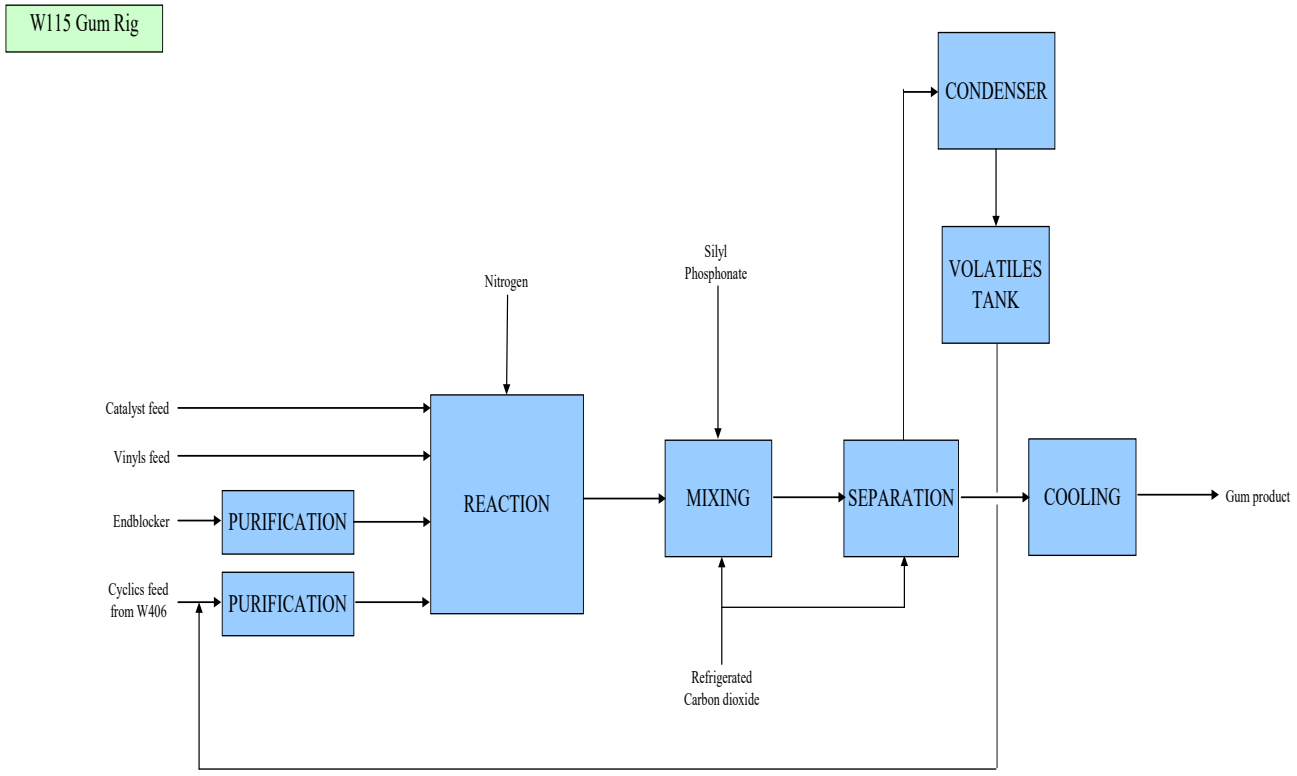
15 W115 Elastomers

15.1 Gum Rig Process



Block Diagram of W115 Gum Rig Process

The gum rig process, see Appendix 12, Section 15, Figure 1, produces high viscosity polymer by feeding cyclic siloxanes, dimethyl vinyl endblocker and a catalyst as raw materials into the process. Cyclic siloxanes from T-581 are pumped through 541/542 molecular sieves to remove trace quantities of water prior to 543 and 5014 cyclics preheaters, which are heat exchangers. 543 preheater is steam based and used for all products while 5014 preheater is hot oil based. The hot cyclic siloxanes are then fed to 545 reactor. Each of the other feed materials are pumped from their respective feed tanks directly into 545 reactor, where cyclic siloxane rings are opened in the presence of a catalyst to form linear molecules which polymerize together to form long chains of a high molecular weight polymer known as 'Gum'. This reaction is an equilibrium reaction.

Reaction in 545 reactor:

$(Me_2SiO)_4$ + $Me_2ViSi(OSiMe_2)_xOSiViMe_2$ + $(MeViSiO)_z$ + Catalyst
D4 Cyclics 2764 Vinyl Endblocker 2287 Vinyl Cyclics

→

$Me_2ViSi(OSiMe_2)n(OSiMeVi)_mOSiViMe_2$ + $(Me_2SiO)_y$
Gum vinyl polymer ~ 85% Cyclics ~ 15% (y=3-20)

The gum and volatile product mixture exits the bottom outlet of the reactor and into the 546 mixer, where the catalyst is neutralised. The 546 mixer moves the neutralised gum and volatile product mixture forward into 522 evaporator, which is operated under vacuum conditions, and strips off the volatiles. These volatiles are condensed in 529 condenser and recycled back to join the reactor feeds via 530 volatiles tank. The neutralizing agent is supplied to the 546 mixer and the 522 evaporator base from a dedicated skid. The stripped gum exits 522 evaporator by the bottom outlet and is pushed forward by 523 pump to the 596 gum cooler. The cooled

gum is then discharged into kegs. A final injection of catalyst neutralizing agent is fed into the gum exit stream. Different types of gums are made by varying small quantities of additives to the process.

Depending on the gum product, different grades of gum purity can be achieved by using hot oil as a heating medium in addition to steam. By using hot oil, low volatiles gum can be produced. Hot oil is provided to 5014 preheater and 522 evaporator by the hot oil unit which consists of 5026 heater, 5023 expansion tank and a circulation pump.

The Gum Rig has the following modes of operation:

1. Steam only – normal volatiles gum
2. Steam and Hot Oil – normal volatiles gum
3. Steam and Hot Oil – low volatiles gum

15.1.1 Plant equipment and reactor conditions:

Description	Equipment volume (m3)	Operating pressure (barg)	Operating temperature (°C)	Notes Eg exotherms, catalysts etc
581 Cyclics feed tank		0-1	40-60	
509 Vinyl Endblocker		0-1	20-30	
508 Vinyl Cyclics tank		0-1	20-30	
594 Catalyst Feed Tank		0-1	25-35	catalyst
541/542 Molecular Sieves			40-60	
543 Cyclics Pre-heater			50-175	Steam
5014 Cyclics Preheater		3.2	180-240	Hot oil
545 Reactor		3	175-240	Steam
522 Evaporator		6 mbara	180-290	Hot oil
540 liquid knock out pot		6 mbara	220	
529 vent condenser		4 mbara	220-25	
536 vent condenser		0-1	40-25	
600 additive		0-1	20-30	
596 Gum Cooler		25-35	275-80	
5173 Clean Water Drum	0.5	5	30	
5174 Start-up Heater		9	30 to 80	
5175 Water Interchanger		5	45 to 30	
530 Volatiles tank			25-35	
550 Additives Skid				
5023 oil expansion drum		0.2	150	
5026 oil heater		4	267-280	

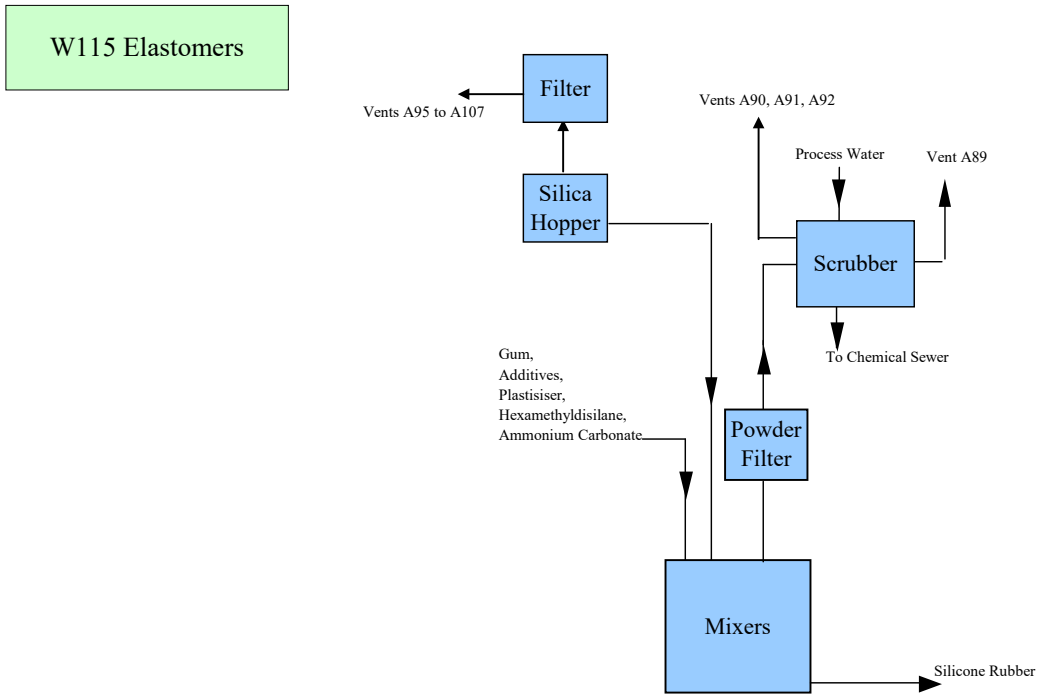
15.1.2 Gum rig Process Control for Emission Minimisation

Vent Description	Continuous? Y/N	Emission Minimisation Techniques in place
A94 Gum rig vent from 536 condenser	Y	536 condenser condenses out unreacted volatile siloxanes via a process water heat exchanger before venting to atmosphere. Resulting releases of siloxanes and cyclohexane are below the BAT benchmark for class B VOCs and any further abatement is therefore unnecessary
594 Catalyst feed vent	N	This vent is considered environmentally insignificant

15.2 ~~Catalyst Unit~~ (this is no longer in use)

15.3 Mixing Plant

15.3.1 Process Description



Block Diagram of W115 Mixing Process

W115 has four mixers used for batch manufacturing silicone rubber base, see Appendix 12, Section 15, Figure 3. Gum is charged to each mixer via the open lid. Secondary treating agents are also charged in this manner. The lid is then closed and the mixer purged with nitrogen until the oxygen content is below the explosive limit of 6%.

A filter is located on each mixer vent line to ensure silica dust is not vented to atmosphere. When the oxygen level is below 6% a reverse jet cleandown sequence is active, cleaning the filter every few minutes. Reverse jetting the filter drops silica powder back into the mixer ensuring the vent filter does not blind and the correct amount of silica is dosed to the mixer.

An in-line oxygen analyser is used to monitor the mixer oxygen content throughout each batch. Once the oxygen level is below the explosive limit, the mixer drives start and the addition of silica can then commence. Silica is gravity fed into the mixer from a hopper located above it via a bin activator and rotary valve set. Once the mixer blades and silica charge have started, the required quantities of fluids are pumped into the mixer. After adding the silica and fluids, the mixer contents are blended to a uniform consistency.

Once the mixing is completed, the mixer drive is stopped. The tilt mixers are tipped and the base dropped into a base tray and sent to storage.

Material is also discharged from the Bottom discharge mixers. The logs are cut to a specified weight, wrapped, placed in boxes, strapped, then transferred to W204 warehouse.

15.3.2 Hexamethyldisilazane bases

Hexamethyldisilazane (HMDZ) fluid is dosed into one of the tilt mixers as a treating agent. This material liberates small quantities of ammonia during the mixing process, which is vented to a packed column water scrubber and is removed by addition of process water to the scrubber.

The mixing process for HEXAMETHYLDISILAZANE bases can be described as follows:
Addition of siloxane polymer to mixer
Addition of silica and hexamethyldisilazane to mixer
Addition of water to mixer
Heat up and stabilisation of base
Addition of other fluids
Additional mix
Empty mixer

Note that steps 2 and 3 can be reversed for different products

Hexamethyldisilazane reacts with water:

$(CH_3)_6Si_2NH + 2H_20 \rightarrow 2(CH_3)_3SiOH + NH_3$
Hexamethyldisilazane Trimethylsilanol ammonia

The trimethylsilanol is used in the base manufacturing process as an agent which enables siloxane polymer to mix with silica powder. The ammonia leaves the mixer via the vent line on the mixer lid where it passes through a powder filter to a countercurrent packed column scrubber system to remove the ammonia generated.

15.3.3 Ammonium carbonate

Ammonia is also generated from the other mixer processes due to very small (<0.1%w/w) dosings of ammonium carbonate to a number of different bases. Ammonium Carbonate acts as a shelf life enhancer.

The mixing process for bases containing small amounts of ammonium carbonate is as follows:
Addition of siloxane polymer and ammonium carbonate powder to mixer
Addition of other additives to mixer
Addition of silica and plasticiser to mixer
Heat up and stabilisation of base
Addition of inert filler powders
Additional mix for short period
Empty mixer

Ammonium carbonate powder is added to the rubber base. It is blended homogeneously into the base. During mixing some of the carbonate breaks down as follows:

$(NH_4)_2CO_3 \rightarrow 2NH_3 + H_2O + CO_2$
ammonium carbonate ammonia water carbon dioxide

The ammonia gas leaves the mixer via the vent line on the mixer lid where it is filtered to remove powders before passing directly to atmosphere.

15.3.4 Siloxane Volatiles Release

Siloxane volatiles are also vented from the mixing operation when the rubber base increases in temperature due to the frictional action of the blades. The siloxane volatiles are present in the gum product added at the beginning of the mixing operation.

15.3.5 Emission Control Techniques

The vent gas passes out of a single vent line from the mixing vessel, through a filter to remove any powder entrained in the vent gas to a scrubber. The scrubbed liquor (ammonium hydroxide) is sent to chemical sewer and treated in the site's Waste Water Treatment unit. The remaining ammonia gas passes to atmosphere through a stack at a height of 20 metres above ground level.

The process control system for this procedure has an operator interface which prompts the operator to put the scrubber on line for HMDZ processes.

137 and 157 mixer have an upgraded LEV system around the lids due to manual loading of powder bags. This is to protect personnel whilst the mixer is being loaded. There is a HEPA 13 filter on the LEV with a fully contained powder removal system.

15.3.6 Ammonium Carbonate

Ammonium carbonate is weighed out at a small weigh station with local exhaust vent in W115.

15.3.7 Plant equipment and reactor conditions

Description	Equipment volume m^3	Operating pressure barg	Operating temperature °C	Notes Eg exotherms, catalysts etc
157 mixer		0.5-0.9	120-160	
277 mixer		0.5-0.9	120-160	
177 mixer		0..5-0.9	120-160	
137 mixer		0.5-0.9	120-160	

15.3.8 Mixer Process Control for Emission Minimisation

Vent Description	Continuous? Y/N	Emission Minimisation Techniques in place.
A89 137 mixer vent	N	Ammonia is scrubbed from the vent using a water scrubber (139) and the resulting aqueous ammonia stream sent via the chemical sewer for on-site effluent treatment. The system is configured so that the process cannot operate unless the minimum scrubbing water flow is satisfied. Monitoring and subsequent air dispersion modeling work under IPC deemed the vent to be environmentally insignificant.
A90 157 mixer vent	N	Ammonium carbonate particulates are abated through the use of dust cartridges (with typical retention of 20mm using BS2831 Test dust No2) which gives a removal efficiency of approximately 98%.
A91 177 mixer vent	N	Ammonium carbonate particulates are abated through the use of dust cartridges (with typical retention of 20mm using BS2831 Test dust No2) which gives a removal efficiency of approximately 98%.
A92 277 mixer vent	N	Ammonium carbonate particulates are abated through the use of dust cartridges (with typical retention of 20mm using BS2831 Test dust No2) which gives a removal efficiency of approximately 98%.
A130	Y	Filter. Local releases of particulates around the 137 and 157 mixer lids during manual bag offloading are abated via a back pulsed filter which is HEPA 13 99.95% of particulates removed
Powder weigh station extraction vent	N	Used infrequently and considered environmentally insignificant

15.4 Mixer Silica Hoppers and Silo

A 13 m^3 (working capacity) Silica hopper is installed above each W115 Mixer.

Fumed silica is fluidised in air and sent either from Cabot or from the onsite silica silos to each Silica hopper.

Each Silica hopper is installed with weighing devices and a rotary valve at the bottom of the vessel to control the amount of silica added to the mixer. Nitrogen is injected into each hopper to fluidise the silica during silica charging from hopper to mixer. This is to prevent silica collecting on the sides of the hopper.

Each hopper is installed with a separate filter system to prevent any silica particles escaping to atmosphere and they are designed for >99% efficiency.

The onsite silica silos can only receive silica from locally unloaded silica containers or road tankers. The silo is installed with a pulsed filter system to prevent silica particles escaping to atmosphere and the filters are designed to comply with BAT.

15.4.1 Plant equipment conditions

Description	Equipment working volume m^3	Operating pressure barg	Operating temperature °C	Notes Eg exotherms, catalysts etc
141 Hopper		0-0.2	Amb	
161 Hopper		0-0.2	Amb	
188 Hopper		0-0.2	Amb	
288 Hopper		0-0.2	Amb	
Silica silos x 4	200 x 4	0-0.2	Amb	

15.4.2 Silica Hopper control for Emission Minimisation

Vent Description	Continuous? Y/N	Emission Minimisation Techniques in place.
A95 188 vent	N	189 Bag Filter. Releases of particulates are abated via a nitrogen back pulsed fabric filter to meet BAT benchmark performance of <20mg/m^3 for particulate releases. There has been no historical evidence of particulate releases from this vent
A96, A97, A98, A99 288 vent	N	252 Bag Filter. Releases of particulates are abated via a nitrogen back pulsed fabric filter to meet BAT benchmark performance of <20mg/m^3 for particulate releases. There has been no historical evidence of particulate releases from this vent
A100, A101, A102, A103 161 vent	N	162 Bag Filter. Releases of particulates are abated via a nitrogen back pulsed fabric filter to meet BAT benchmark performance of <20mg/m^3 for particulate releases. There has been no historical evidence of particulate releases from this vent
A104, A105, A106, A107 141 vent	N	142 Bag Filter. Releases of particulates are abated via a nitrogen back pulsed fabric filter to meet BAT benchmark performance of <20mg/m^3 for particulate releases. There has been no historical evidence of particulate releases from this vent
A126	N	Filter. Releases of particulates are abated via a back pulsed filter to meet BAT benchmark performance of <10mg/m^3 for particulate releases.
A127	N	Filter. Releases of particulates are abated via a back pulsed filter to meet BAT benchmark performance of <10mg/m^3 for particulate releases.

Vent Description	Continuous? Y/N	Emission Minimisation Techniques in place.
A128	N	Filter. Releases of particulates are abated via a back pulsed filter to meet BAT benchmark performance of <10mg/m^3 for particulate releases.
A129	N	Filter. Releases of particulates are abated via a back pulsed filter to meet BAT benchmark performance of <10mg/m^3 for particulate releases.

15.5 Compounding Unit W205

15.5.1 Process Description

W205 Compounding Unit consists of a variety of mixers, mills and extruders, see Figure 4. The mixers are small units suited for making small quantities of rubber product. The primary function of the Compounding unit is to blend bases with additives to form compounds for sale.

Bases are the largest component of each mix and are usually made by W115 mixer units. The additives include filler powders, fluids, colouring pigments, inhibitors and catalysts. However no reaction takes place in the mixers – only blending of the raw materials until a uniform consistency is reached.

The products once mixed are shaped using two Roll Mills or high pressure extruders into a variety of shapes and log sizes. These are then packed into cardboard boxes for transport to customers.

15.5.2 Emission Control Techniques

Each mixer and extruder is vented to an extraction unit in W205 Compounding, which is used to collect any silicon powders vented by the equipment during its operation.

15.5.3 Plant equipment conditions

Description	Cell	Equipment volume m^3	Operating pressure barg	Operating temperature °C (Note 1)	Notes Eg exotherms, catalysts etc
BDM 1 5420 Mixer	Cell 1	0.41	Atm	20-80	
BDM 2 1420 Mixer	Cell 2	0.41	Atm	20-80	
BDM 3 2420 Mixer	Cell 3	0.41	Atm	20-80	
BDM 4 4420 Mixer	Cell 4	0.41	Atm	20-80	
3401 Tilt Mixer	Cell 5	0.80	Atm	20-80	Nitrogen purged
3601 Tilt Mixer	Cell 6	0.91	Atm	20-80	
6420 Tilt 2 Mixer	Cell 6	0.42	Atm	20-80	
3301 Small FSR Mixer	Cell 6	0.10	Atm	20-80	Also used in Cell 7
3302 Small lot mixer	Cell 7	0.07	Atm	20-80	
7420 Small lot mixer	Cell 7	0.42	Atm	20-80	
4 x 2 Roll Mills	*	n/a	Atm	20-80	Shared between cells
10 x Ram Extruders	*	n/a	Atm	20-80	Shared between cells
CTM 95	TBD	TBD	Atm	20-80	

Description	Cell	Equipment volume m^3	Operating pressure barg	Operating temperature °C (Note 1)	Notes Eg exotherms, catalysts etc
CTM 145	TBD	TBD	Atm	20-80	
CTM 315	TBD	TBD	Atm	20-80	
CTM 355	TBD	TBD	Atm	20-80	

Note 1 – Mixer temperature is determined by batch recipe.

15.5.4 Mixer Process Control for Emission Minimisation

Vent Description	Continuous? Y/N	Emission Minimisation Techniques in place.
Main extraction	N	Bag Filtration. Vent considered environmentally insignificant.
Small lot extraction	N	Bag Filtration. Vent considered environmentally insignificant.
Powder weigh station extraction	N	Bag Filtration. Vent considered environmentally insignificant.

15.6 W204 Warehouse

W204 Warehouse is a building which is used to store W115 Rubber Base products before being loaded onto trailers and shipped to the customer destination. W204 is a single storey building (approximately 4 m in height) 22 m width and 84 m length. W204 also stores a raw material required in the manufacture of silicon rubber products in W115 and W205 Compounding. These are also listed below:

W115 Products:

Silicon Rubber Bases

W115/W204 Raw Materials:

Minusil 10 (Silica powder)