START-UP AND OPERATING MANUAL

FOR

390 TON PER DAY NITRIC ACID PLANT

FOR

RADFORD ARMY AMMUNITION PLANT

RADFORD, VIRGINIA

BY

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ATLANTA, GEORGIA

SECTION B

PROCESS DESCRIPTION

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It is advisable to use the flow sheets 151-101, 151-102, 151-103, and 151-104 in conjunction with the following description. Atmospheric air is filtered through the air intake filter and then compressed to approximately 134 psia in a centrifugal compressor set. The high pressure air leaves the compressor at approximately 174° C. The air then enters the shell side of the air heater where it is heated to approximately 238° C. before entering the ammonia-air mixer to be mixed with the ammonia.

The liquid ammonia is supplied from the ammonia header. It flows into the ammonia vaporizer-superheater and is vaporized with circulating hot condensate at approximately 35° C., and the gas then flows through the superheater section where it is heated to 182° C. The gas is then filtered to remove any foreign material which may harm the platinum-rhodium gauze. It is important that the gas be superheated before going to the ammonia-air mixer and the gauze. Low temperatures could allow ammonia condensation which can cause gauze damage or preconversion.

The 232° C. ammonia-air mixture is then reacted on the platinum-rhodium gauze at a temperature of approximately 916° C. The hot process gas then passes through the heat exchanger train.

The heat exchanger train has four (4) main functions:

1) To cool the gas before entering the absorber column.
2) To recover heat in the form of hot gas to drive the expander.
3) To recover heat by the generation of steam.
4) To preheat air to the converter.

The process gas leaving the condensate cooled converter elbow enters the tube side of the waste heat exchanger and gives up heat to generate steam. The gas then enters the air heater where the air to the converter is preheated. The gas leaving the air heater enters the tail gas heater where the tail gas in the shell is heated before entering the tail gas interchanger and combustor. The gas leaving the tail gas heater next passes through the platinum filter where it is filtered to recover any platinum catalyst which may have been lost from the gauze.

The gas then enters the cooler condenser where secondary air is added and is cooled to approximately 43° C. During this stage of cooling, the water which was formed at the gauze is condensed and reacts with the nitrogen dioxide to form weak nitric acid. The weak acid and process gas then flow to the absorber. The gas flows up through the tower where product strength nitric acid is formed by the reaction of the nitrogen dioxide and water. The weak acid is pumped into the tray of the tower where a matching acid concentration exists. Cool condensate is introduced into the top of the absorber column to complete the water requirements.

The product acid formed flows through the bleach section of the absorber before it discharges from the absorber. Cooled air from the compressor is used to strip the NO_2 from the acid.

The tail gas leaving the top of the absorber passes through a mist eliminator where any entrained liquid is removed. The tail gas is then reheated in order to drive the hot gas expander. This is accomplished by heating the tail gas in the tail gas preheater (with steam), tail gas heater, and tail gas interchanger and combustor.

The tail gas from the tail gas heater enters the tail gas interchanger where it is heated to 466° C. by the hot tail gas exit the combustor. Natural gas is then mixed with the hot tail gas prior to flowing into the combustor. The natural gas reacts with the nitrogen oxides and oxygen in the tail gas in the combustor catalyst bed. The tail gas exits the combustor at 861° C. and is cooled to 677° C. by passing through the tail gas interchanger before the gas enters the hot gas expander.

The tail gas leaves the expander at 338° C. and passes through the shell side of the economizer and treated water heater giving up heat to the boiler feed water and treated water make-up. The tail gas exits at 186° C. and is discharged through the exhaust stack.

SECTION C

EQUIPMENT DESCRIPTION

AIR INTAKE FILTER ITEM 201

The intake air filter is designed to receive air to the compressor at atmospheric pressure. The design capacity is 44,000 ACFM (90° F. and 13.65 psia).

AIR COMPRESSOR ITEM 202A

The compressor is to consist of the following items: One (1) Ingersoll-Rand Type META-4FIC/E520, which consists of a 4-stage, two casing centrifugal compressor with two integral intercoolers. The capacity rate is 36,739 SCFM dry air at 133.65 psia discharge pressure.

EXPANDER ITEM 202B

The expander is designed to recover power from the acid plant. Gas inlet conditions are 677° C. and 98.65 psia and a discharge pressure of 14.45 psia at 338° C. The design gas flow to the expander is 136,204 #/hr.

STEAM TURBINE ITEM 202C

The Terry Model GHF multi-stage steam turbine has a design inlet steam condition of 250 psig and 208° C. The turbine will supply 3000 horsepower during start-up and will have an expected make-up horsepower of 770.

SURFACE CONDENSER ITEM 204

The surface condenser is designed to condense the steam used to drive the turbine. The condensate is then pumped to the condensate tank.

SURFACE CONDENSER PUMPS ITEMS 205 A&B

Individual pump capacity is 95 GPM at 30 psig. One pump is operating; one is a spare. The condensate is pumped to the condensate surge tank.

AMMONIA VAPORIZER ITEM 207A

The vaporizer is designed to receive liquid ammonia at 35° C. and has an operating pressure of 185 psig. The capacity is 9484 #/hr. of ammonia. Hot condensate on the tube side is used for vaporization of the ammonia.

AMMONIA SUPERHEATER ITEM 207B

The superheater is designed to superheat 9484 #/hr. of ammonia at 35° C. to an outlet temperature of 182° C. and an operating pressure of 185 psig using steam. The vaporizer and superheater are contained in a common shell.

AMMONIA FILTER ITEM 209

This filter is designed to receive 9484 #/hr. of superheated ammonia. It has an operating temperature of 182° C. and an operating pressure of 180 psig.

AMMONIA-AIR MIXER ITEM 211

The ammonia-air mixer is designed to handle ammonia and air at 232° C. at 115 psig. Capacity is 9484 #/hr. ammonia and 135,210 #/hr. air.

CONVERTER ITEM 212

The design capacity of the converter is 144,694 #/hr. of ammonia and air mixture at a pressure of 115 psig. A condensate cooled elbow acts as a transition from the gauze to the waste heat boiler.

WASTE HEAT BOILER ITEM 214

The function of this exchanger is to produce steam. The process gas (tube side) enters at 889° C. and exits at 355° C. The operating pressure of the shell side is 255 psig. The steam production will be 50,095 #/hr. An accumulator is provided for steam release.

AIR HEATER ITEM 210

The air heater is designed to handle 135,210 #/hr. of air (shell side) with an inlet temperature of 174° C. and an outlet temperature of 238° C. The design pressure is 135 psig. The design flow of process gas (tube side) is 144, 694 #/hr. The tube side inlet and outlet temperatures are 371° C. and 329° C. respectively, and the design pressure is 135 psig.

TAIL GAS HEATER ITEM 215

The tail gas heater is designed to handle 134,847 #/hr. of tail gas (shell side) with an inlet temperature of 93° C. and an outlet temperature of 260° C. The design pressure is 120 psig. The design flow of process gas (tube side) is 144,694 #/hr. The tube side inlet and outlet temperatures are 345° C. and 217° C. respectively and the design pressure is 135 psig.

COOLER CONDENSER ITEM 216

The cooler condenser is designed to handle process gas on the tube side with an inlet temperature of 217° C. and process gas-acid outlet temperature of 43° C. Design pressure is 125 psig and normal operating pressure is 110 psig. Cooling water flows through shell side.

ABSORBER TOWER ITEM 218

The absorber has 27 bubble cap trays and is designed for 120 psig with an operating pressure of 105 psig. The design temperature is 93° C. with an operating temperature of 49° C. Bleaching is accomplished on 4 sieve trays in the base of the absorber tower. A mist eliminator at the top gas exit prevents liquid entrainment.

TAIL GAS PREHEATER ITEM 220

The tail gas preheater is designed to receive tail gas at 35° C. and 100 psig. The outlet temperature of the tail gas is 93° C. Condensing steam on the shell side provides the heating.

EXHAUST STACK ITEM 221

The purpose of the exhaust stack is to provide sufficient elevation for the discharge of tail gas. It is designed for metal temperatures up to 288° C. It is 42 inches in diameter and 49' 11" high.

ABSORBER CONDENSATE COOLER ITEM 224

The condensate cooler is designed to receive condensate on the tube side at 71° C. and 40 psig. The outlet temperature of the condensate is 35° C. Make-up treated water from the softeners on the shell side provides the cooling.

ABSORBER WATER BOOSTER PUMPS ITEMS 236 A&B

Each pump has a capacity of 25 GPM of condensate and design discharge pressure is 160 psig.

PLATINUM FILTER ITEM 225

The purpose of the platinum filter is to reclaim platinum from the process gas. It has a design capacity of 144,694 #/hr. at 110 psig and 213° C.

COMBUSTOR ITEM 226

The tail gas combustor will remove the oxides of nitrogen to provide a colorless discharge from the exhaust stack. It is designed to handle 136,204 #/hr. with an inlet temperature of 454°C. and an outlet of 861° C. Design pressure is 110 psig. Design O_2 (in tail gas) is 3.0% by volume.

TAIL GAS INTERCHANGER ITEM 243

The tail gas interchanger is a U-tube heat exchanger contained in the same shell as the combustor. Its purpose is to preheat tail gas to the combustor to 466° C. from 260° C. using the hot gas exit the combustor. The hot tail gas at 861° C. is cooled to 677° C.

IN-LINE BURNER ITEM 240

The natural gas or butane fired in-line burner is used during start-up to provide sufficient heat to allow reaction of fuel gas over the combustor catalyst. Design heat release is 4,242,000 BTU/Hr.

SUMP PUMP ITEM 229A

The purpose of this pump is to pump collected acid from the sump to the product acid line. The pump has a design capacity of 15 GPM at a design discharge pressure of 50 psig.

NITRIC ACID SUMP ITEM 229B

The sump is used to collect acid from various drain and sample points throughout the plant. It has a total capacity of 185 gallons.

WEAK ACID PUMPS ITEMS 230 A&B

These pumps have a capacity of 40 GPM at a discharge pressure of 175 psig. One pump is operating to deliver weak acid to the proper absorber tray, and the other is a spare.

NATURAL GAS FILTER ITEM 231

The purpose of this filter is to filter all foreign material from the natural gas or butane to prevent damage to the combustor catalyst. It has a capacity of 1500 #/hr. at 160° C. and 140 psig.

BLEACH AIR COOLER ITEM 234

The purpose of this cooler is to cool the bleach air used in the bleacher. Design capacity is 20,835 #/hr. of air with an inlet temperature of 174° C. and an exit temperature of 119° C. Operating pressure is 120 psig. Cooling water is used on the shell side.

PRODUCT ACID COOLER ITEM 237

This cooler is designed to cool product acid exit the absorber on the tube side from 49° C. to 32° C., using cooling water on the shell side.

ECONOMIZER ITEM 241

The economizer is designed to receive boiler feed water on the tube side and recover heat from tail gas on the shell side after it has passed through the expander. Boiler feed water enters the tubes of the economizer at 108° C. and exits at 187° C. and 275 psig. Tail gas enters the shell side at 338° C. and exits at 220° C. and 0.5 psig. The economizer and treated water heater are contained in a common shell.

TREATED WATER HEATER ITEM 242

The treated water heater is the final stage of heat recovery from the tail gas before going to the stack. Treated water from the condensate cooler enters the tube side at 34° C. and leaves at 65° C. Tail gas on the shell side enters at 220° C. and exits to the stack at 186° C. and 0.2 psig.

WATER TREATMENT PACKAGE ITEM 260

The treatment package consists of a dual train fixed bed sodium zeolite system. The filtered water is softened by the treatment and used as make-up water in the deaerator and boiler feed water system. The unit is completely automatic in continuous operation. The capacity of the unit is 78 GPM per design basis water analysis.

CONDENSATE SURGE TANK ITEM 263

This tank provides surge capacity for both the absorber feedwater and the circulated condensate system through the converter elbow and ammonia vaporizer.

CONDENSATE TRANSFER PUMPS ITEMS 264 A&B

The pumps are primarily used to circulate condensate through the converter elbow and ammonia vaporizer back to the condensate tank. It also delivers excess condensate back into the deaerator and condensate to the suction of the absorber water booster pumps for absorber feedwater. One operating and one spare.

DEAERATOR ITEM 265

The purpose of the spray type deaerator is to receive recycled condensate and make-up treated water, remove dissolved gases and heat water using steam, and to act as a surge tank for the boiler feed water system. The deaerator operates at 5 psig using steam from boiler feed water pump turbine and the steam header. The deaerator is designed for 30 psig to full vacuum and 149° C.

BOILER FEED WATER PUMPS ITEMS 266 A&B

The vertical turbine type pumps are provided to deliver boiler feed water from the deaerator through the economizer to the steam accumulator on the waste heat boiler. Design capacity is 135 GPM at 325 psig discharge pressure. The main operating unit is steam turbine driven using 250 psig steam, back pressured to 5 psig and discharging into the deaerator. The standby unit is electric motor driven.

BOILER FEED WATER TREATMENT PACKAGE ITEM 267

This package consists of two units, each consisting of a mix tank and metering injection pump. One unit is provided to deliver hydrazine to the deaerator to provide oxygen scavenging and pH control. The other unit is provided to deliver a mixture of sodium phosphates for scale control and neutralizing amine for condensate return line corrosion control to the steam accumulator on the waste heat boiler.

AIR ENTRAINMENT SEPARATOR ITEM 268

A separator is provided for knock-out of condensed or entrained liquids from the utility air supplied for use as instrument air to the dryer.

INSTRUMENT AIR DRYER ITEM 270

This completely automatic dual tower unit is designed to dry 60 SCFM air to -40° C. dewpoint. It operates on an 8 hour NEMA cycle, 4 hours drying, and 4 hours reactivation and cooling. The reactivation is ccomplished by heating with embedded electric heaters and purging dessicant with small flow of dry air from other tower. A prefilter, capable of oil removal, and an afterfilter are provided.

BUTANE VAPORIZER-SUPERHEATER ITEM 252

Liquid butane is received at 16° C., vaporized at 82° C. and 140 psig, and then superheated to 132° C. on the shell side of this heat exchanger. Condensing 250 psig steam on the tube side provides the heat.