A Model Project

Continuing Advances in 3D CADD Systems

SF Phosphates Filtration and Evaporation Expansion Project

Authors: **Rich Antila, Bob Skorcz, Jim Osborn and Steve Traum**

Project Description:

For SF Phosphates, minimizing capital, operating and maintenance costs, an aggressive project schedule and high product quality were absolutely necessary to meet the demands of the highly competitive fertilizer marketplace. Their decision to apply 3D CADD systems in a cooperative effort with a highly skilled team with extensive experience in 3D CADD execution resulted in major cost and schedule savings under the aggressive budget and schedule approved by the SF Phosphates management.

SF selected Mustang Tampa, Inc. to meet the following project objectives:

Project	84,000 MTPY P205 Filtration and Evaporation Expansion
Budget (Total Installed Cost)	$36,000,000
Engineering and Design	Mustang Tampa, Inc.
Procurement	Mustang Tampa, Inc.
Construction Management	SF Phosphates
Schedule	22 months
Major Equipment:	UCEGO® No. 11 Filter 3rd Stage Evaporator Clarifier - 38 ft. diameter Acid Storage Wet Scrubber
Process Buildings	Control Room Steel Structures - 1100 tons

Project History:

When SF Phosphates expanded their phosphoric acid processing capacity in 1998 by adding 84,000 MTPY of new P_2O_5 filtration and evaporation capacity, they selected Mustang Tampa, Inc. as their detailed engineering contractor. By November of 1999, this project was completed significantly under budget and well ahead of schedule, allowing early production and product sales. Design errors and rework in the field were minimal.

To achieve this level of success, SF Phosphates and Mustang applied an execution strategy that focused on the philosophy that the highest quality detailed engineering and design would result in lowest equipment and construction cost and minimum project schedule. The metrics for a successful project were defined to include the most effective balance of total installed cost, product quality, minimum operating, maintenance and life-cycle costs, meeting the required completion and start-up schedule and, of course, safety to personnel, the local community and the environment.

The front-end engineering effort employed many of the fundamentals and "Best Practices" embraced by the Construction Industry Institute (CII) and Independent Project Analysis, Inc. (IPA).

Some of the important elements that brought added value to the project included: team building; a detailed project execution plan; design optimization; constructability analysis; early operations and maintenance input and training; commissioning/start-up considerations; and rigorous cost, schedule and quality controls.

A major overall contributor to the success of this project was utilization of a 3D CADD model as a foundation for the entire project implementation effort. The 3D CADD model provided enhanced project visualization and a greater dimension of information from project inception through completion. From the start, SF Phosphates and Mustang team members, including all engineering disciplines, procurement, construction, operations, maintenance and safety personnel were active participants in a single team effort.

Continuing Advancements in 3D CADD Systems and Applications

3D CADD systems have improved substantially over the past decade. When used by thoroughly trained and experienced engineering, design, procurement and construction professionals, the benefits of 3D CADD extend from project inception through start-up, and continue in long-term operation and maintenance of the facility.

A decade ago, the primary benefit of 3D CADD was that design errors were reduced and interference problems were caught before construction commenced. As a result, the cost and time lost in correcting design errors and interference problems that reached the field were reduced. Beyond this, 3D CADD offered only minor benefit at that stage of development.

As with all computer systems, 3D CADD has benefited over the past ten years from continuing advances in computer equipment and software, as well as from training and experience in their use. Today, 3D CADD systems provide value in all phases of a project from concept through startup and plant operation.

In a moment, we will discuss the details of how the 3D CADD system benefits a project through each project phase, but as an overview, it is important to understand the major changes. Ten years ago, the use of 3D CADD generally required more engineering and design manhours and greater systems costs (engineering materials) than conventional design methods. In addition, nearly all 3D CADD projects were large-scale grassroots facilities. At that time, it was relatively impractical and uneconomic to use 3D CADD on small projects or on revamp/expansion of existing facilities.

Today, however, we are able to implement 3D CADD projects for the same or fewer engineering and design manhours and lower total cost. In addition, we are able to cost-effectively implement 3D CADD projects as small as several million dollars, including both grassroots and revamp or expansion projects.

SF Phosphates 3D CADD Model Development Phases

Phase I – Model Study (Illustration 1)

During the study phase of the SF Phosphates project, the following information was built up in the 3D CADD block model:

- All Items were modeled to full size
- The project was modeled at true plant coordinates or at plant monument coordinates
- Basic steel columns, beams and major floors
- Basic equipment shapes and any maintenance zones
- Minimum detail - basic blocks to develop and improve layout
- SF Phosphates reviewed the block model with Mustang, maintenance, and operations personnel. This review process helped to create a single project team.

Phase II - Detailed Model Development (Illustration 2, Photo 1)

The block model created during the study phase was carried forward into the Detailed Model Development Phase. The following additional information was added to the 3D CADD model:

- Equipment with nozzles were modeled to vendor dimensions, including insulation.
- Piping, including pipe supports and inline instruments were placed in the model by use of a Relational Data Base containing all the piping material class data. **(Illustration 3, Photo 2)**
- The Relational Data Base included all material specifications and dimensional standards, e.g. flanged valves to B16.10 etc.
- Stress Isometrics were extracted for stress analysis.
- Civil foundations, trenches etc. were modeled.
- Steel columns, beams and bracing were modeled using specific standards for dimensional data and physical properties.
- The steel model had physical loads added for equipment, pipe, wind etc, to allow it be passed to an analysis package to verify that steel members met code requirements.
- Any items with a physical size to be considered were modeled using catalog information including; drop out areas, maintenance access, safety routes, cables trays, junction boxes, safety showers etc. **(Illustration 4)**
- During the design modeling phase interference checks were run on a regular schedule and any Interference's were resolved.
- Mustang and SF Phosphates reviews of model were done monthly during detail design.
- Electronic tagging of review comments was recalled to ensure that appropriate action was taken.
- Drawings were available to be extracted and printed at any time.
- Material take-off information was extracted at various points of the project to show a materials "snap shot" at any particular point during development.

Phase III – Design Production and Construction

During the Design Production and Construction Phase of the SF Phosphates project, the 3D CADD data model was used to:

- Conduct pre-bid reviews with construction bidders and equipment vendors and suppliers
- Achieve virtual elimination of construction rework
- Assure correct materials and quantities were available in the field at the right time
- Improve construction planning and inter-trade coordination
- Enhance Construction Scheduling
- Improve task visualization, planning and supervision
- Extract Material Take-Off's
- Extract equipment nozzle reports
- Extract piping General Arrangement drawings and piping isometrics **(Illustrations 5 & 6)**
- Extract structural drawing
- Extract backgrounds for Instrument and Electrical

3D CADD Model Design Review

The SF Phosphates 3D CADD model was used as a powerful tool for reviewing the design as it was being developed, from the block model stage, through the final detailed model. The model was viewable from any point within, around, above or below the plant. A copy could be printed at any location or section without concern for corrupting the model in any way. Powerful user definable display sets were created to filter information and to allow viewing of any plant component. **(Illustration 7, Photo 3)**

To further facilitate review of the design, objects, equipment, structural, piping and other plant components in the model could be color coded or hidden to simplify review. The following additional design review capabilities were also helpful:

- Move objects
- Search and find objects
- List object information
- Tag comments with saved views, restore previous tagged comments to check to see if action has been completed
- Print screen at any point
- Use true plant coordinates to move around
- Walk around (encircle) items
- Create "movies" of the entire model
- Use of the model as an electronic data warehouse indexing tool

Major Benefits of 3D CADD Model on SF Phosphates Project (Illustration 8)

The SF Phosphates and Mustang team was able to take advantage of the 3D CADD system and implementation methods, which provided the following benefits to the Filtration and Evaporation Project.

- **EARLY INPUT TO DETAILED DESIGN BY ALL PROJECT TEAM MEMBERS**

  The most effective use of 3D CADD systems is achieved when development of the 3D CADD model is initiated very early during the project lifecycle. This should be during the conceptual stage, or at least during the preliminary engineering work. Reaching agreement on process flow diagrams and P&ID's is very important early in the project.

  Applying 3D CADD early provides early visualization of the new facility as it develops, so that the full project team, including client management, process, engineering, operations, maintenance and safety leaders, clearly understand the project from inception through design development and throughout the entire project lifecycle. This assures full understanding and agreement of the project scope and virtually eliminates scope growth and change as the project progresses through detailed design, procurement, construction and start-up.

  On the SF Phosphates project, these factors provided early visualization of the completed plant and facilitated input from all project participants, thus encouraging early agreement on design, construction, operation and maintenance concepts. As a result, total project cost and schedule was minimized at every stage of project implementation.

  When appropriate, the 3D model can also be used as a platform to demonstrate the new facilities to customers and to local interest groups and citizens. The 3D model conveys a clear message that the company is using the most advanced tools and systems to build state of the art facilities that will meet or exceed all customer requirements, as well as environmental and safety mandates and expectations.

- **ENHANCED COMMUNICATION BASE**

  The 3D model provides an excellent communications tool to facilitate information exchange among all project participants at various locations. In addition to the engineering contractors home office location, this can include the client's engineering and project site, major vendor locations, etc.

  There are several options for establishing a convenient communications mode:

  1. The 3D model can be placed on a secure website, with access limited to designated project team members. Comments can be attached to the model, or "live" teleconferencing can be conducted. To assure control of changes, only the engineering contractor's personnel would be authorized to modify the model.

  2. The 3D model can be loaded onto electronic medium and distributed over night for review and comment at various locations. This is usually done weekly, bi-weekly or monthly.

3. Interactive design review can be conducted in person at any convenient location, using readily available PC hardware and design review software.

For the SF Phosphates Project, the second option was selected for simplicity and an electronic copy of the "in-progress" model was sent to SF every six weeks for review. As a result, communication and cooperation during the work was excellent and travel of SF personnel to visit Mustang in Tampa from Rock Springs, Wyoming to review the design was limited to only three trips.

- **CONSTRUCTION OPTIMIZATION**

The 3D model allows the entire project team, including construction management personnel, to interactively review all details early during design development and as work progresses through detailed design. This contributes value in the following main areas:

1. Constructability Studies - The 3D model provides an excellent tool for conducting detailed constructability studies to assure that the most practical, safe and economic construction methods are being utilized.

2. Pre-Bid "Walk-Through" – Upon commencement of the construction bidding cycle, a visual "Walk-Through" of the 3D model can be conducted with the construction bidders to provide a clear understanding of the project scope and construction details. The enhanced visualization of construction requirements provided by 3D CADD reduces construction unknowns and contingency and improves task planning and installation.

3. On-Site Communications - As the project progresses from the engineering office to the field, the model moves to the field as well. This provides an excellent communications tool for the site team and construction subcontractors for work planning and for coordination of all inter-discipline activities on-site.

4. Site Safety Assurance – The 3D model is used very effectively for site safety training, rigging for heavy or complex lifts, equipment movement and many other safety-critical field activities.

5. Minimize Field Rework - In the field during construction, a quality 3D model typically results in the reduction of field rework due to design errors to less than 1% of the total installed project cost. (Construction Industry Institute statistics report that the average rework on non-3D projects is in the range of 4% to 8% of total installed cost.)

6. Operator and Maintenance Training, Commissioning Systems and Start-up – As the construction approaches completion, the 3D CADD model is a very helpful tool to familiarize and train operations and maintenance personnel at the plant level with the new facilities, prior to start-up. As a result, personnel were better prepared to implement the required tasks and activities.

- **LIFE-CYCLE DATABASE MANAGEMENT FOR SAFE AND ECONOMIC PLANT OPERATION AND MAINTENANCE**

  The value of the 3D model can be extended beyond engineering and construction by creating a Life-Cycle Database Management System. This database can be configured to include all project drawings, design documents, equipment specifications and mechanical catalogs, and can be expanded to include operator and maintenance training modules, Just-in-Time maintenance planning, record keeping, maintenance/repair videos, parts inventory planning and warehousing and a variety of additional enhancements. As a result, the overall long-term cost of ownership and operation of facilities is reduced.

3D CADD Software and Hardware Requirements

The 3D CADD Design Model can be reviewed using SmartPlant Review. According to Intergraph, "SmartPlant Review is a complete Microsoft Windows visualization environment for interactively reviewing and analyzing large, complex 3D models of process plants". "SmartPlant Review allows in-depth data and 3D model navigation for design, construction and maintenance with a familiar Microsoft user interface." Additional information can be obtained by visiting the website: **www.ingr.com/visualization/spr.asp**

SmartPlant Review requires a typical PC with the following minimum capacities or better:

- 400 MHz
- 128 MB Ram
- 4 GB Hard Drive
- APG 8MB Graphic Card
- 21" Monitor (PC can also be connected to an electronic screen projector for group viewing.)

Lessons Learned

Among the most important lessons learned is the fact that 3D CADD is far advanced beyond what the systems were capable of delivering just a few years ago. All of the 3D CADD value enhancements, when taken together, can seriously reduce total project cost and schedule. The SF Phosphates Filtration and Evaporation Project is hands-on proof of the value of experience, teamwork and 3D CADD systems.

Mustang Tampa, Inc. – Team Experience with 3D CADD

The Mustang Tampa, Inc. team has been using 3D CADD systems on many engineering, procurement and construction projects for more than ten years. In 1989, our team of personnel began the first large-scale 3D CADD project, which was a $110 million chemical plant to produce non-CFC refrigerant. The project was successfully completed well under budget and schedule and the plant was subsequently expanded to double and quadruple the original capacity very cost effectively, by using the original 3D CADD model.

Since that time, the Mustang team has implemented in excess of $1 billion worth of 3D CADD projects. All have been completed on time, within budget and with exceptionally low design error rates and field rework cost. In most cases, projects have been implemented starting at the conceptual stage and continuing through start-up, on fast-track schedules in record time.

Over this eleven-year period, the 3D CADD system software and hardware have improved substantially and the Mustang team has optimized our system application methods to a great degree. Today, Mustang is using 3D CADD tools on projects as small as $2.5 million, with great effect. We have also developed techniques to apply 3D CADD methods to revamp projects, as well as grassroots or brown-field projects.

The true key to successful implementation of 3D CADD projects is not the systems software or hardware, but the people who are applying the tools. Mustang has developed among the very best 3D CADD methods, execution capabilities and experience in the process industries. We have proven this many times over for our clients.

AUTHORS BIOGRAPHS:

RICH ANTILLA - Construction Project Management Team, Maintenance Coach, SF Phosphates. In addition to insuring the SF Plant is well maintained, Rich is a St. Louis Rams Fan and one of Wyoming's premier ice fishermen.

BOB SKORCZ - Construction Project Management Team, Operations Technical Coach, SF Phosphates. In addition to producing phosphoric acid at the SF Plant, Bob is one of Wyoming's most consistently successful elk hunters.

JIM OSBORNE - Expansion Project Engineering Coordinator, Engineer, SF Phosphates. In addition to handling phosphate engineering projects, Jim is a 32 year St. Louis Rams fan and lives to fish – mostly for Salmon, Yellow Fin Tuna and Wahoo.

STEVE TRAUM - Vice President of Mustang Tampa, Inc. Responsible for Business Development and Sales. In addition to creating client awareness of Mustang's superior services, Steve is a Buc's fan and an avid spear fisherman and sailor.

ILLUSTRATION 1. BLOCK MODEL OF EVAPORATOR BUILDING

Mustang Tampa, Inc.

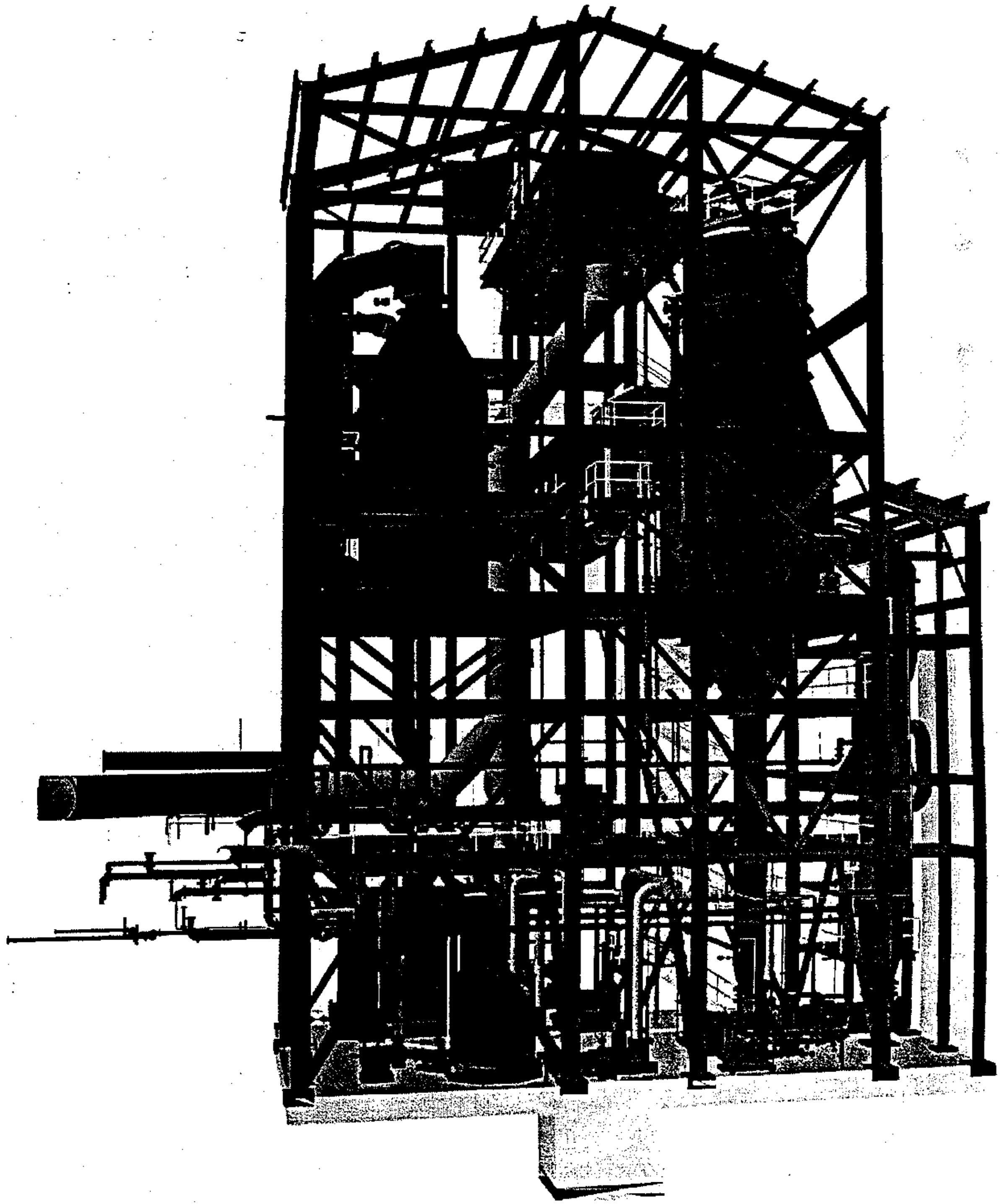


ILLUSTRATION 2. DETAILED MODEL OF EVAPORATOR BUILDING

Mustang Tampa, Inc.

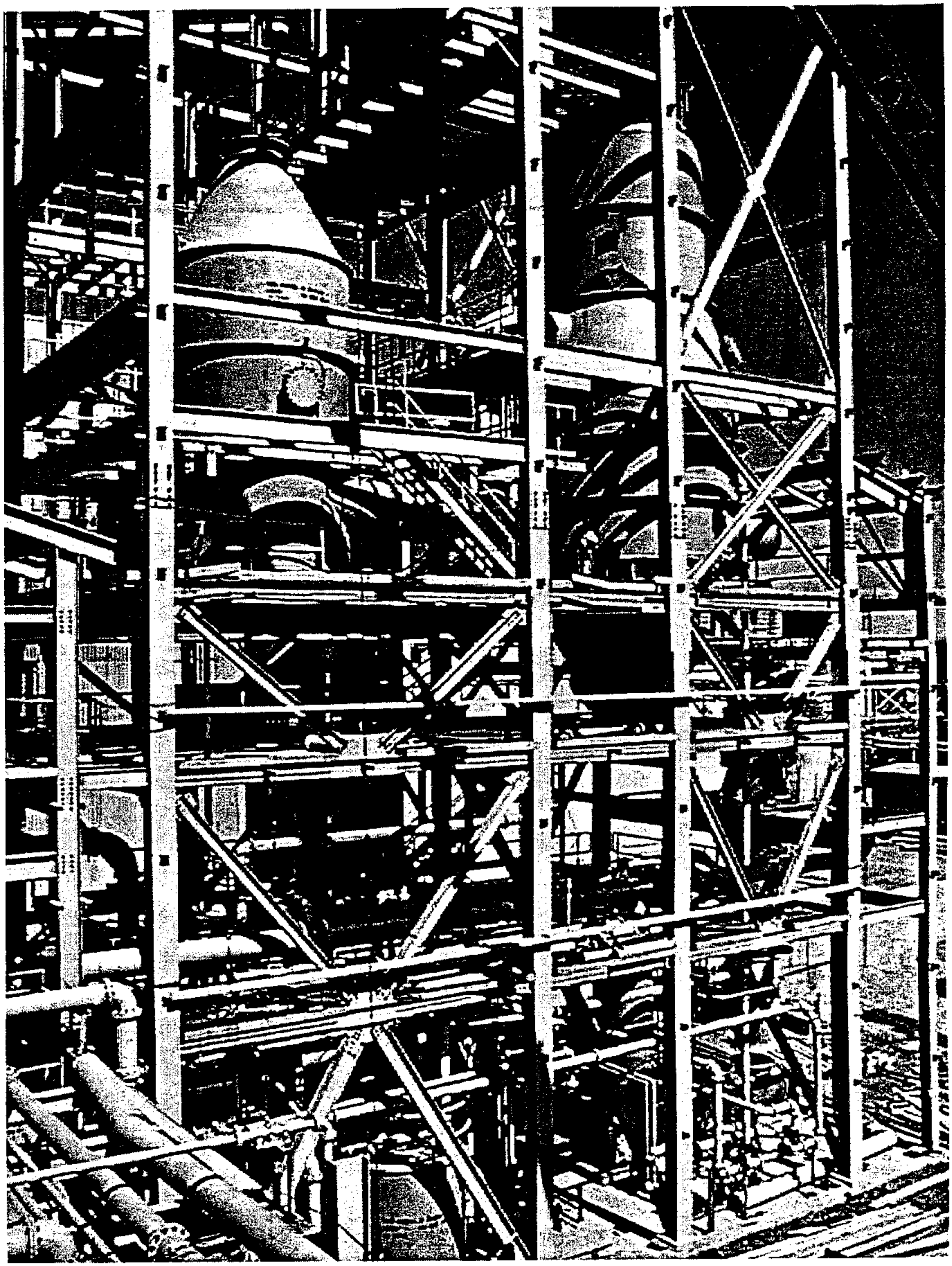


PHOTO 1. DURING CONSTRUCTION

Mustang Tampa, Inc.

ILLUSTRATION 3. PUMPS IN 3D MODEL

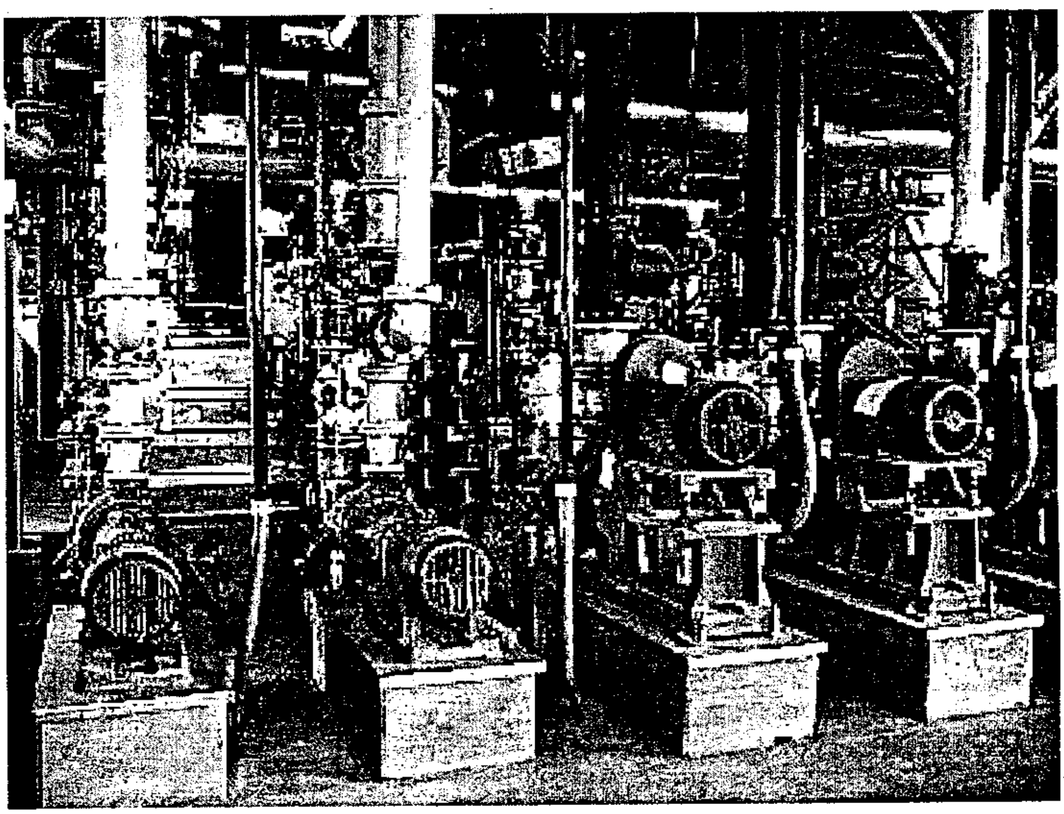


PHOTO 2. PHOTO DURING CONSTRUCTION

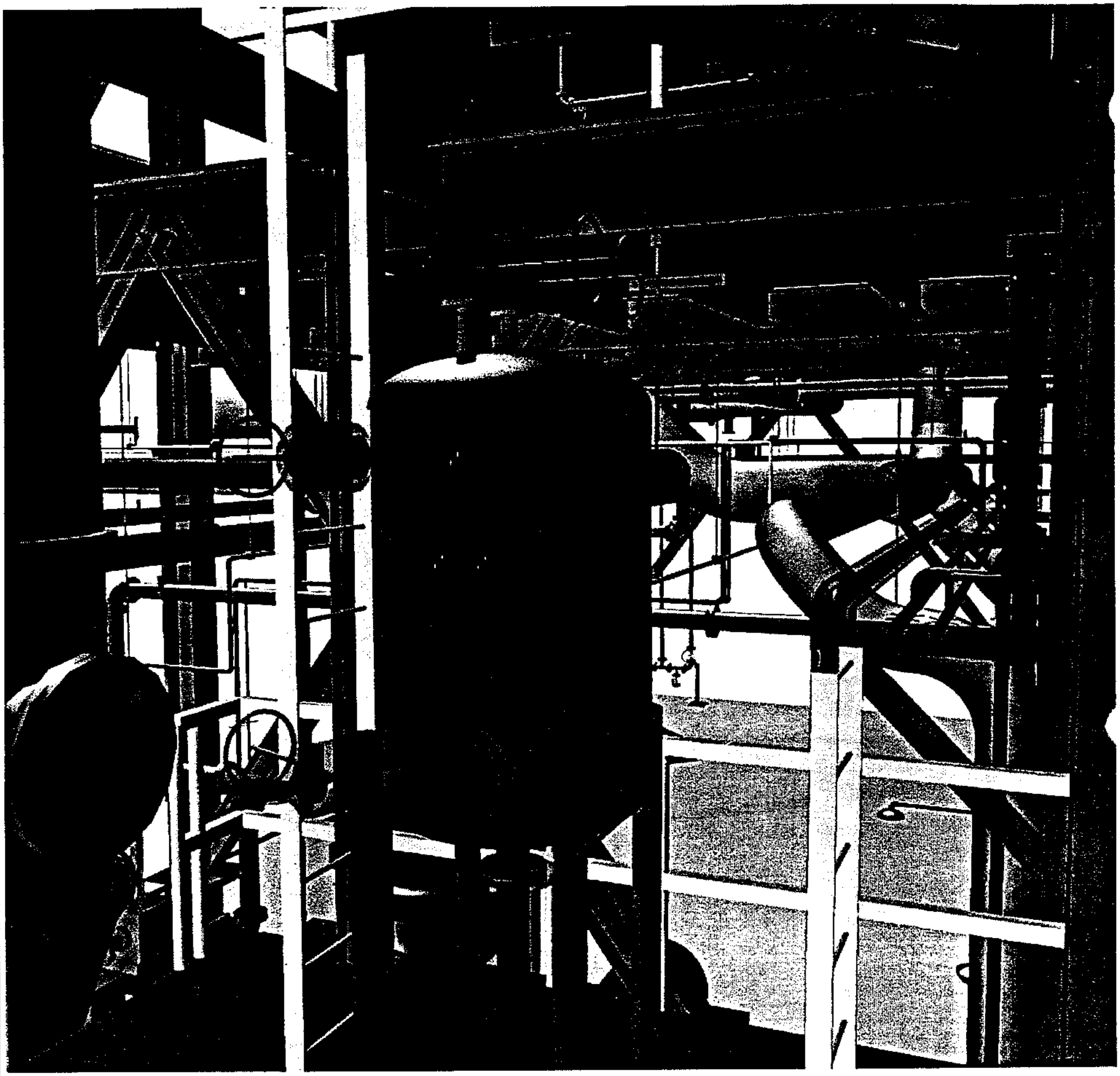


ILLUSTRATION 4. VESSEL DETAILS

Mustang Tampa, Inc.

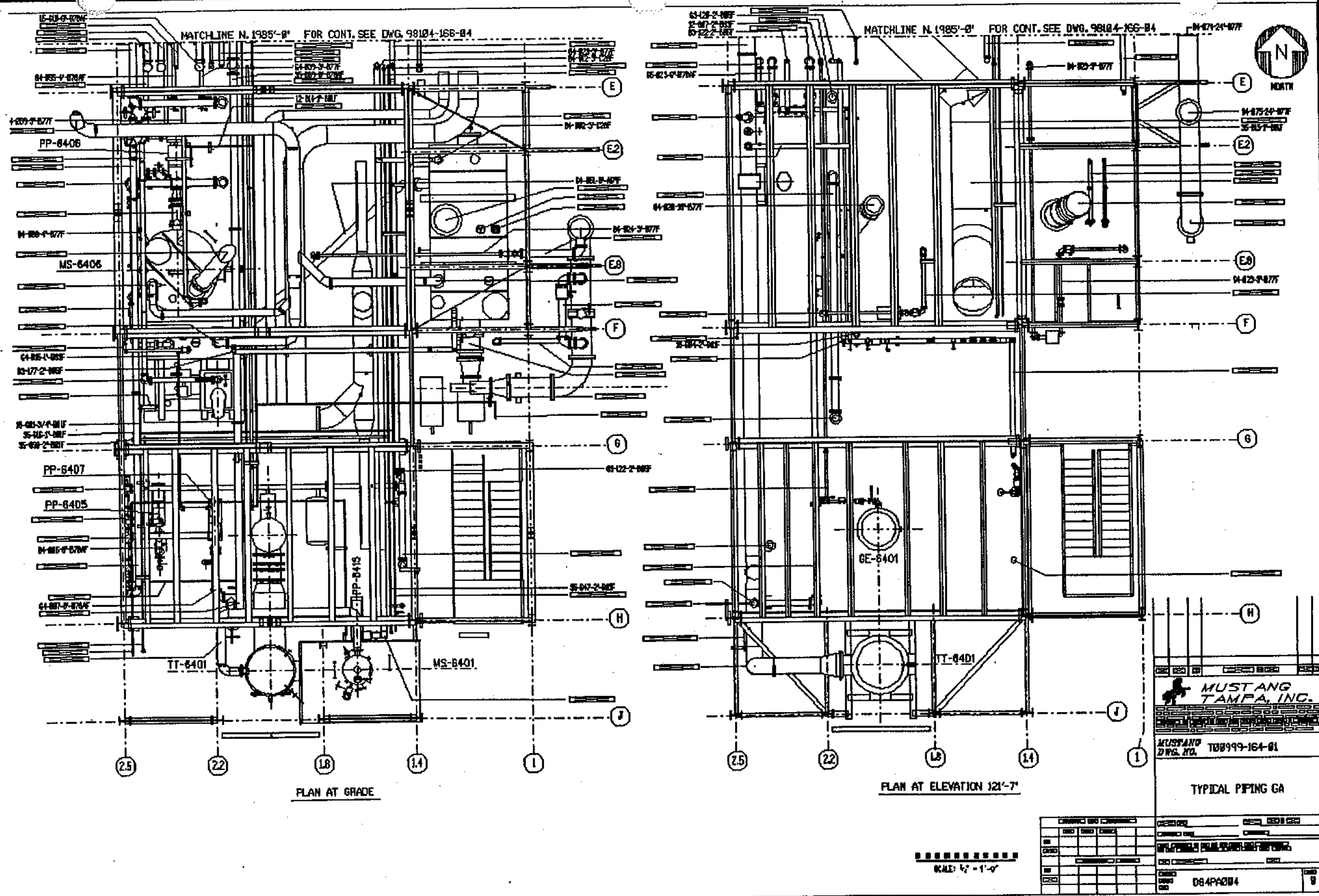
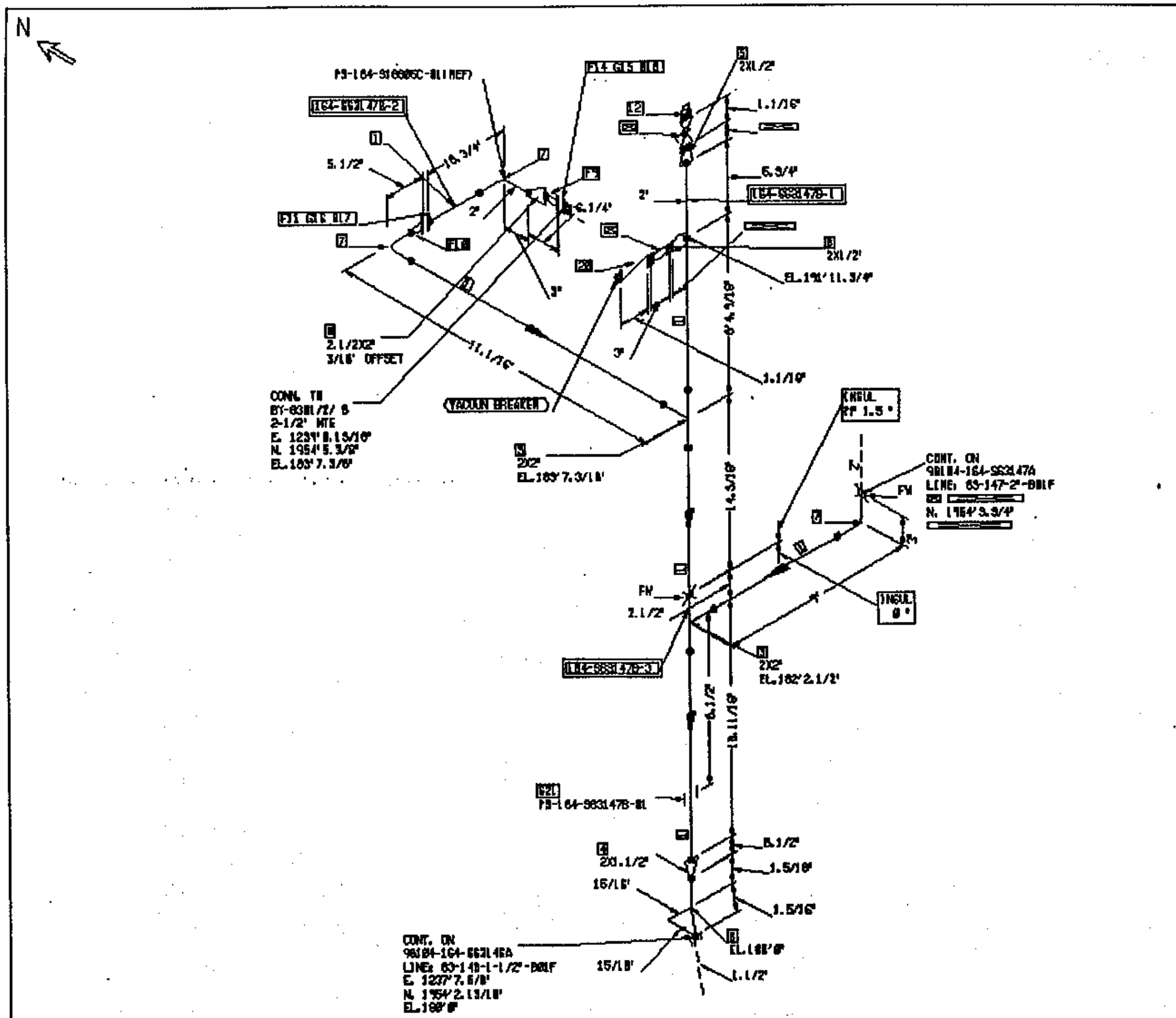


ILLUSTRATION 5. TYPICAL PIPING GA

Mustang Tampa, Inc.



BILL OF MATERIAL

: SHOP MATERIALS :

PT NO	DESCRIPTION	SIZE (INCHES)	ITEM CODE	QTY
1	CRW PIPE, STD WT, BE, BLK & A53-B TYPE E	2	P.11.HHR05	13.1'
2	ECC RED, BW, STD WT, CS A234-WPB	2.1/2X2	TWR.G.R01	1
3	TEE, BW, STD WT, CS A234-WPB	2X2	TWRC.G.R00	2
4	C SW NIP, SCH 80, LB/SP, CS A234-WPB	2X1.1/2	N.02.GA.00	1
5	C SW NIP, SCH 80, LB/ST, CS A234-WPB	2X1/2	N.02.GA.02	1
6	SOCT. SW. 3000. FS A105	2X1/2	TS20H0...00	1
7	90 ELL, BW, STD WT, CS A234-WPB	2	TW00.G.R00	3
8	90 ELL. SW. 3000. FS A105	1.1/2	TS00 TO...00	1
9	WN FLG, 150, STDWT BORE, FF, FS, A105	2.1/2	F.0200.R0	1
10	WN FLG, 150, STDWT BORE, FF, FS, A105	2	F.0205.R0	1
11	SO FLG, 150, FF, FS, A105	2	F.0300...00	1

: FIELD MATERIALS :

PT NO	DESCRIPTION	SIZE	ITEM CODE	QTY
12	SR PLUG, TE, FS A105	1/2	TT09.G...00	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	SCRD FLG, 150, FF, FS-GAL A105	2.1/2	F.0050L.01	1
15	GASKET. 150. FF. SYNTH 1/16 THK	2.1/2	G.708...01	1
16	GASKET, 150, FF, SYNTH 1/16 THK	2	G.708...01	1
17	HH BOLT, MS, A307B, A563 HH NUT, 2.75" BOLT LENGTH	5/8	B.17.....00	4
18	HH BOLT, MS, A307B, A563 HH NUT, 3.0" BOLT LENGTH	5/8	B.17.....00	4
19	BALL VALVE, 400, THRD, BRONZE, APOLLO 71-100 OR EQ.	1/2	BA0101	1
20	CHECK VALVE, 125, SCRD, BRONZE, BACK, CRANE 37 OR EQ.	1/2	CA0102	1
21	PIPE SUPPORT - TYPE 52	2	PS-164-SS31478-01	1

PIPE SPOOLS

NOTES:
1. DIMENSIONS ARE TO CENTERLINE OF PIPE AND FACE OF FLANGE OR LINING UNLESS NOTED OTHERWISE.

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OR FOR ORDERING MATERIAL UNLESS DATED AND SIGNED.
APPROVAL ______
DATE ______
STRESS ANALYSIS
STRESS RELIEVING (PWHT) YES

APPROVALS PDS

INSULATION PP 1.5"
TRACING CODE 0
SERVICE CONDITIONS SEE LINE TABLE
COND. SYS.
NDE 0
PAINT SPEC. 10005-10-1010

FOR CONSTRUCTION

MUSTANG TAMPA, INC.

TYPICAL FABRICATION ISOMETRIC

LINE NO. 63-147-2"-B01F 164

B01F D63PI006 T00999-164-SS3147B 0

ILLUSTRATION 6. TYPICAL FABRICATION ISOMETRIC

Mustang Tampa, Inc.

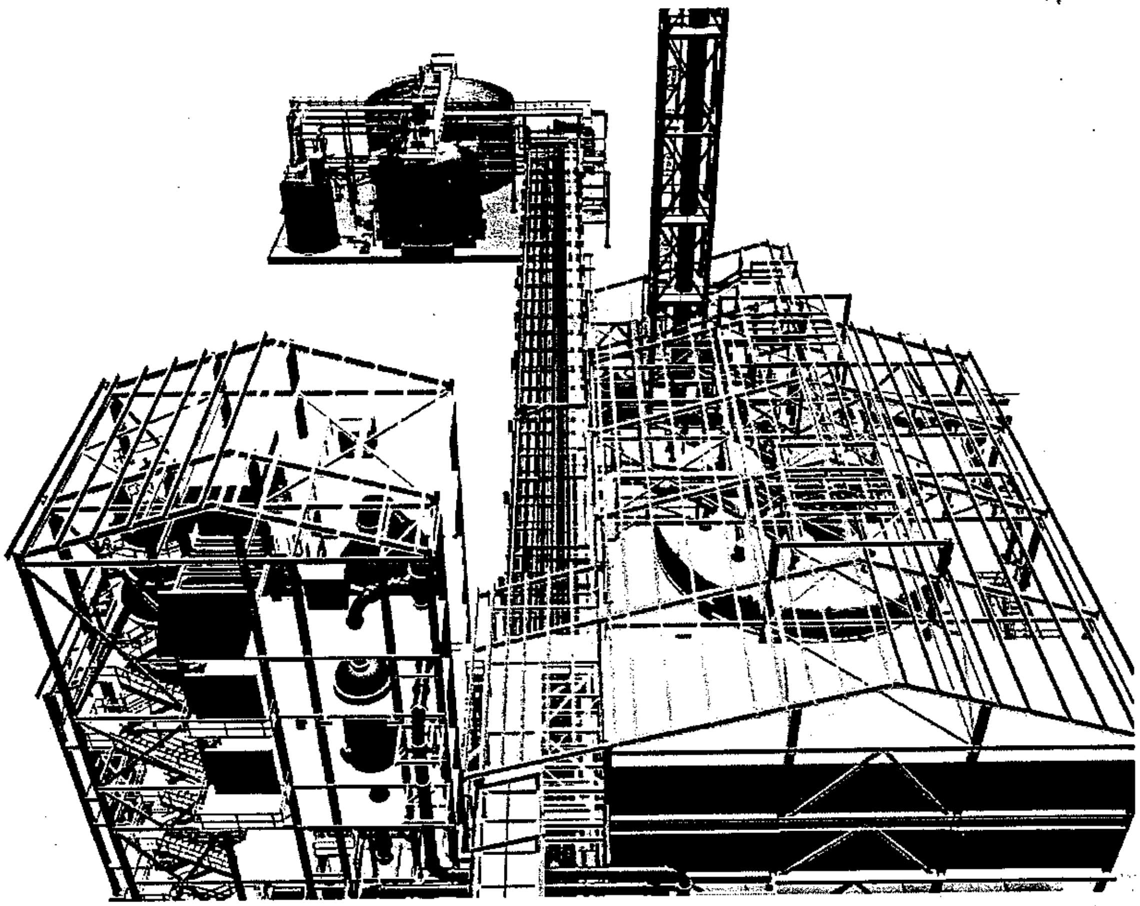


ILLUSTRATION 7. COMPLETE 3D MODEL

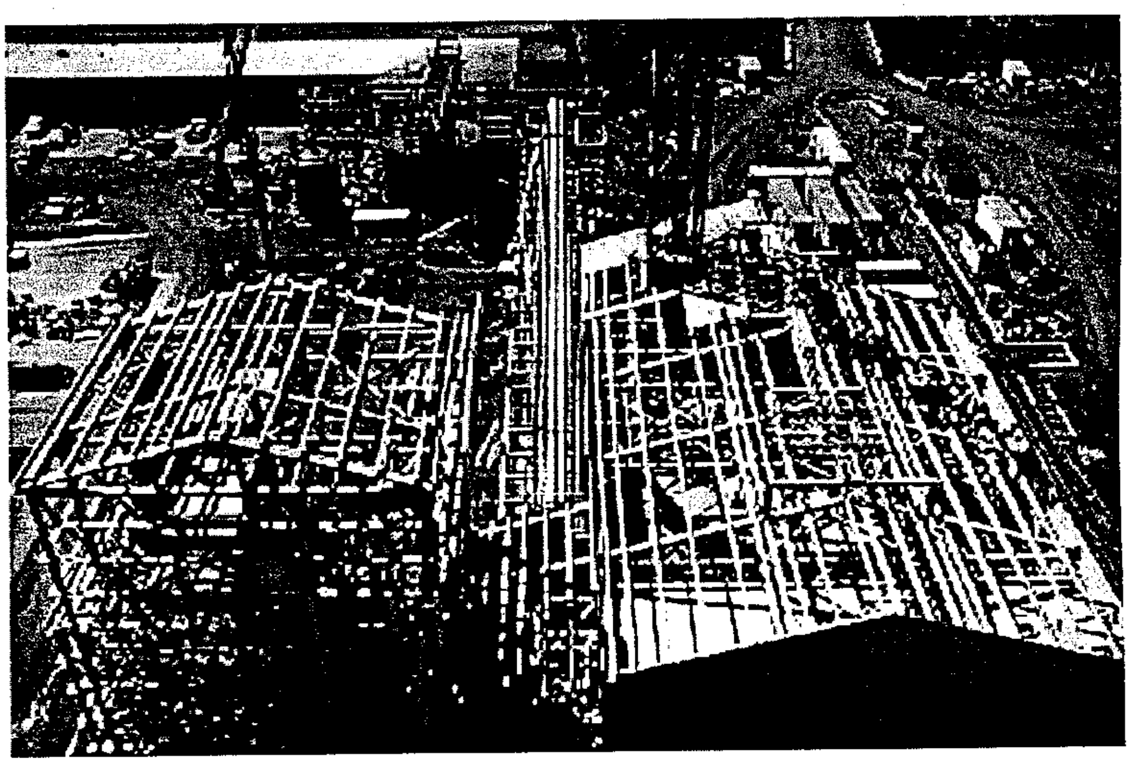


PHOTO 3. PHOTO DURING CONSTRUCTION

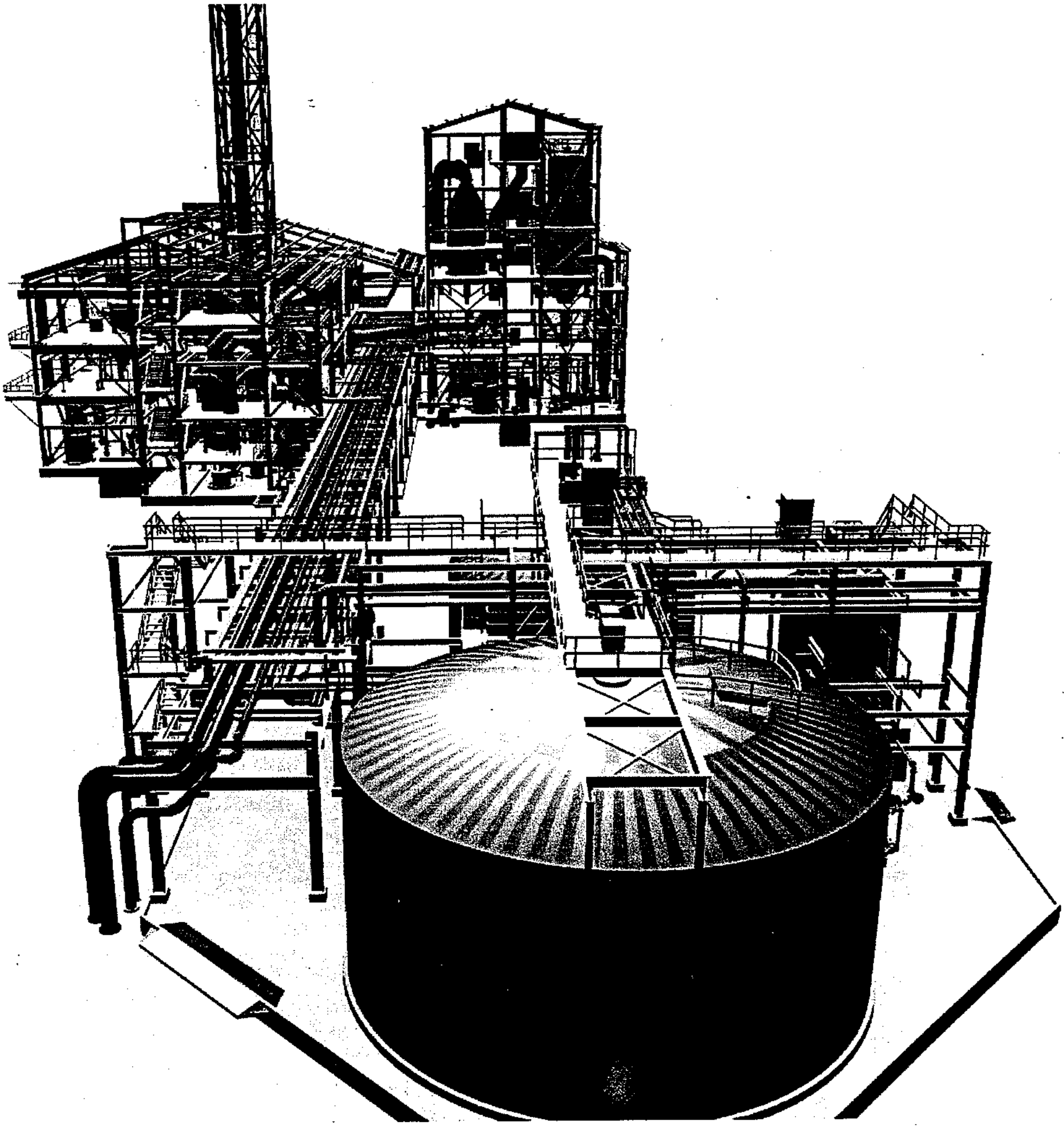


ILLUSTRATION 8. COMPLETE PLANT DESIGN

Mustang Tampa, Inc.