HIGH EFFICIENCY GAS-FIRED DRUM DRYER FOR FOOD PROCESSEION APPLICATIONS

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Preface

The California Energy Commission’s Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
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- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

*High Efficiency Gas-Fired Drum Dryer for Food Processing Applications* is the final report for the project (contract number 500-06-018) conducted by Gas Technology Institute. The information from this project contributes to PIER’s Industrial/Agricultural/Water End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission’s website at [www.energy.ca.gov/research/](http://www.energy.ca.gov/research/).
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Abstract

In California, processing dried and dehydrated fruits and vegetables, and evaporated and condensed milk, consumes an estimated 14.5 trillion British thermal units each year. Conventional drying metal cylinders, heated from the inside by condensing steam, are used for this process. The use of steam in heated drums requires the drums to meet American Society of Mechanical Engineers codes for pressure vessels, which limits the steam pressure and, consequently, the shell temperature that reduces the drying capacity. In most cases, drying is the most energy-intensive and temperature-critical aspect of food, chemical, and pharmaceutical products processing. The Gas Technology Institute has developed an innovative high efficiency gas-fired drum dryer concept based on the combination of ribbon flame and advanced heat transfer enhancement techniques. The Gas Technology Institute built a commercial-scale gas-fired drum dryer system and evaluated the system at a California food processing industrial host site. The results of the performance evaluation indicated great potential for the gas-fired drum dryer approach to significantly improve energy efficiency and productivity in a wide spectrum of drum drying applications across energy-intensive industries.

Keywords: Drum drying, gas-fired, energy efficiency, energy intensive processes, food processing
Executive Summary

Introduction

In California, processing dried and dehydrated fruits and vegetables consumes an estimated 6.2 trillion British thermal units (TBtu), and processing evaporated and condensed milk consumes an estimated 8.3 TBtu total energy per year. Both areas use conventional drying metal cylinders which are heated from the inside by condensing steam. Drum drying or drum heating is also used in a variety of other food processes and other industries, such as the pharmaceutical and textile industries.

Using steam requires the drums to meet the American Society of Mechanical Engineers codes for pressure vessels, which limits the steam pressure and, consequently, the shell temperature that reduces their drying capacity. In most cases, drying is the most energy-intensive and temperature-critical aspect of food, chemical, and pharmaceutical products processing.

The new gas-fired drum dryer approach allows a significant increase in the surface temperature of the dryer, increasing the drying rates. Therefore, successful development of the gas-fired drum dryer provides large energy savings to the industry. It will increase energy efficiency from 60-70 percent (steam-operated) to 75-85 percent (gas-operated). The ability to tailor heat transfer along the drum could also lead to product quality enhancements or new product opportunities for California producers.

Project Overview and Approach

The overall objective of the project was to successfully develop and field test a full-scale gas-fired drum drying technology in an industrial food processing production environment while providing high efficiency and operating at low nitrogen oxide (NOx) emission levels.

The Gas Technology Institute with its industrial partners and a participating California food processing host site, designed, engineered, fabricated, installed, and evaluated the gas-fired drum dryer for the selected application in California.

Project Results

The Gas Technology Institute developed an innovative high efficiency gas-fired drum dryer concept based on the combination of ribbon flame and advanced heat transfer enhancement technique (Figure 1). The pilot-scale gas-fired drum dryer unit was designed, fabricated, and successfully tested for a paper drying application (Figure 2). This was followed by the development of a high efficient drum dryer for the California food processing industry, and the installation and evaluation of the high efficient drum dryer at a participating host site.
Figure 1. Gas-Fired Drum Dryer concept (U.S. Patent 6,877,979)

Source: Gas Technology Institute

Figure 2. Pilot-scale Gas-Fired Drum Dryer Unit
Photo Credit: Gas Technology Institute
Gas Technology Institute and its manufacturing partners and sponsors have invested more than $2,000,000 in the successful development and testing of the gas-fired drum dryer technology. The gas-fired drum dryer system was developed per the specifications of a selected California food processor and evaluated in a production environment at the participating host site (Figure 3). A license agreement for this technology has been negotiated and is in the final execution stage by Groupe Laperrier & Verreault USA Inc., one of the leading drum dryer manufacturers. Commercialization of gas-fired drum dryer technology assumes manufacturing and marketing the gas-fired drum dryer system through the existing network of sales representatives.

![Figure 3. Full-scale Gas-Fired Drum Dryer system](Photo credit: Gas Technology Institute)

**Conclusions and Recommendations**

Evaluation of the installed single-drum system at the participating food processing site clearly demonstrated the following major benefits:

- Increased production capacity over the traditional double-drum steam-heated system currently employed by the industry.
- Low emissions produced by the internal combustion system with a turndown ratio 5:1 that meets California regulations.
- The possibility of varying the drum rotation speed and surface temperature for optimal production adjustment when processing products with different specifications.
- The possibility of using different gaseous fuels such as natural gas, liquefied petroleum gas, syngas, and landfill gas.
Benefits to California

Successful implementation of gas-fired drum dryer technology throughout the qualified California food processing applications will result in significant energy savings within the state’s industrial market.
1.0 Introduction and Purpose

1.1. Background: Food Processing in California

California is the top agricultural state in the nation, a position it has held for 50 years. As a natural result, California is also the largest food processing employer in the United States. With an enormous variety of crops, great growing conditions, and increasing demand for prepared food products, California is the center for food processing by shipping $50 billion worth of food products annually (Shoemaker 2006).

California produces a wide variety of food products and is the leading state in many food categories. California surpasses Wisconsin in milk production, and is one of the top ten potato producers. California is the only state producing such specialty foods as almonds, artichokes, raisins, prunes, olives, dates, figs, and pistachios. California’s famous produce products are the ingredients in everything from soup to nuts. Crops grown in California may be lightly processed or they may go through many steps before reaching the market.

In California, processing dried and dehydrated fruits and vegetables consumes an estimated 6.2 trillion British thermal units (TBtu), while processing evaporated and condensed milk consumes an estimated 8.3 TBtu total energy per year (Sikirica, Chen et al 2003). Both areas use conventional drying metal cylinders which are heated from the inside by condensing steam. Drum drying or drum heating is also used in a variety of other food processes and other industries, such as the pharmaceutical and textile industries.

Drying and thermal processing of food products for the purpose of preservation for further use is one of the most energy-intensive areas of California industry. That is why cost-effective solutions and technologies for drying improvements are of major interest to the state.

1.2. Drum Drying

Control and improvements to the efficiency of the drying process for food products (Figure 4) is very complex due to the variability of the raw materials and the variety of drying methods, including:

- Rotary dryers
- Spray dryers
- Band dryers
- Tray dryers
- Drum dryers
- Tunnel dryers
- Fluidized bed dryers
- Pneumatic dryers
- Freeze dryers
One of the most economical drying methods is drum drying. Drum drying is a continuous indirect heating process. In this operation, food slurry is brought into contact with a hot, revolving drum to form a thin layer on the drum’s surface. After sufficient residence time to allow the evaporation of water, the product is removed from the drum by a scraper device (called a doctor blade) located usually one-half to three-quarters of a revolution from the point of application. Factors affecting the rate of drying and final moisture content include:

- Residence time on the drum.
- Surface temperature.
- Film thickness.

The method of such dehydration can only be applied to food slurries or liquid food systems and the product must be able to withstand high temperature-short time exposures without undergoing severe quality changes. This method has been most successfully applied to potato drying and has also been used to dry milk, soup mixes, baby foods, and fruit purees.

The California food processing industry employs several types of drum drying equipment to dry the product, the majority of which are single drum and double drum steam-heated systems with different feeding types (Figure 5).
Figure 6 shows a typical single drum system with multiple satellite application rolls for drying high-viscosity liquids or pasty materials such as mashed potatoes, applesauce, fruit-starch mixtures, gelatin, dextrine-type adhesives, synthetic resins, and various starches. Heat has to be supplied to separate the water from the food. The minimum quantity of heat that will remove the required water is that which is needed to supply the latent heat of evaporation; therefore, one measure of efficiency is the ratio of that minimum to the energy actually provided for the process. Sensible heat can also be added to the minimum quantity, as this added heat in the food often couldn’t be economically recovered.
1.3. Energy Efficiency

Energy efficiency in drying is of obvious importance as energy consumption is such a large component of drying costs. Basically, energy efficiency is a simple ratio of the minimum energy needed to the energy actually consumed.

Different dryers have a number of different operating parameters that, if properly controlled, will result in cost-effective product that is of acceptable quality. Poorly controlled dryers waste energy both directly by consuming more energy than necessary and indirectly by yielding a product that does not meet specifications and must be discarded.

Gas-fired drum drying (GFDD) has much higher energy efficiency (up to 75-90 percent) compared to conventional steam-heated dryers (about 60-70 percent) due to improved convective heat transfer inside the drum as well as to strong potential for advanced heat recovery, which is practically impossible in the case of steam-condensate operations.

Anticipated real-life benefits of the GFDD process could lead to increased production throughput and/or the lowering of energy consumption, and cost
2.0 Project Overview and Approach

The overall objective of the project was to successfully develop and field test a full-scale GFDD technology in an industrial food processing production environment while operating at high efficiency and producing low levels of nitrogen oxide (NOx) emissions. In the course of the project, Gas Technology Institute (GTI), together with its industrial partners and the participating California food processing host site, designed, engineered, fabricated, installed, and evaluated the GFDD for the selected application in California. The original work was designed to be conducted in seven major tasks from October 2006 to December 2009. Task activities included:

**Task 1:** Management and Reporting
- Review meetings and partners coordination
- Monthly and final reporting
- Project administration and communication

**Task 2:** Host Site Selection and Evaluation
- Site selection in California
- Application evaluation

**Task 3:** Concept Design
- Design sketches with supporting analysis
- Final specifications
- Measurement, control, and data collection systems design

**Task 4:** Design Engineering and Fabrication
- Design engineering
- Fabrication, purchasing, and pre-assembling

**Task 5:** Test Plan Development
- Meeting with plant personnel
- Draft test program

**Task 6:** Installation and Shakedown
- Field engineering
- Installation by local contractors with project team support
• Shakedown and operating procedure development

**Task 7: Data Collection, Processing, and Analysis**

• Data collection, processing, and analysis
• Review meeting

This challenging effort is a successful collaboration between GTI, the technology developer; Groupe Laperrier & Verreault USA Inc. (GL&V, the drum dryer manufacturer and technology licensee); Flynn Burner Corporation (FBC, the combustion equipment manufacturer); a major California food processor (the host site); and the California Energy Commission. GTI is the prime contractor and is responsible for the overall execution of the project. GL&V and FBC provided design engineering, fabrication, and installation support, while a major California food processor hosted the GFDD trial and provided the installation and in-kind support to the project team for shakedown and data collection.

**Groupe Laperriere & Verreault USA Inc.** ([www.glv.com](http://www.glv.com))

GL&V is a leader in the North American pulp and paper, chemical, and process industry mid-size dryer market. GL&V currently employs some 1,400 highly motivated people in worldwide locations; these employees are in large part highly trained and skilled technicians, engineers, and business people. From state-of-the-art manufacturing facilities in Canada and the United States, the company delivers to clients worldwide. GL&V also participates in various partnerships on a permanent and temporary basis, all associated with its core business, pulp and paper, food, chemical, or process equipment.

**Flynn Burner Corporation** ([www.flynnburner.com](http://www.flynnburner.com))

FBC has been in business since 1942, manufacturing combustion equipment and systems utilizing direct flame impingement and ribbon burner technology. The company has a strong engineering tradition and serves the food, baking, paper, and plastics industries as well as fossil-fueled utilities. Burners, ovens, and other combustion systems are supplied to all regions in the United States as well as Asia, Canada, and Europe.

### 2.1. GFDD Technology: Description and Design

In a drum dryer, the material to be dried is applied in a thin layer to the outside hot surface of an internally heated rotating drum. The product is dried or heated in contact with the drum and scraped off in the form of a powder or film. GTI has developed an innovative alternative to traditional steam-heated systems. The high efficiency GFDD concept is based on the combination of ribbon flame and advanced heat transfer enhancement technique. A GFDD
system was originally designed and patented by GTI, engineered and fabricated by industrial partners GL&V (Hudson Falls, New York) and FBC (New Rochelle, New York), and installed and evaluated for the full-scale field trial at the host food processing plant. The basic concept allows processing a wide spectrum of food products if implemented in the range from the drum dryer to the rotary drum (Abbasi and Chudnovsky 2005).

Design is a very important step in any development work, including the review of the previous pilot-scale GFDD performance evaluation results (Chudnovsky, Kozlov and Sherrow 2005), technical analysis of the production rate improvement through a baseline audit of the host site steam-heated double drum system, and numerical simulation of the internal drum components (see selected results in Appendix A).

Figure 7 illustrates the simulation results (static temperature) for the drum operating at one million (MM) Btu/hour with a short (45 degrees) and long (90 degrees) combustion product deflector located at 2.75” from the rotating shell.

Detailed analysis of the previous pilot-scale GFDD evaluation demonstrated the strong potential of this technology for further improvement of the thermal processing of the product without serious capital investments. Careful review raised several technical issues associated with the high temperature operation and combustion system ignition which must be addressed before the first commercial unit is installed. These issues include:

- Reliable bearing operation at the elevated temperature.
- Protection of the high voltage ignition wire to provide a reliable ignition by delivering the spark into the right spot of the gas-fired burner.
- National Environmental Policy Act (NEPA) and National Fire Protection Association (NFPA) compliance.
• Capability of the multi-zone combustion system to locate the air/gas mixers (outside of the drum or inside the drum) that linked to the location of the appropriate control valves and programmable logic controllers.

Jointly with the industrial partners’ and participating California food processors’ support, the project team successfully resolved the above issues for the full-scale system evaluation. To simplify the design process and meet the budget and schedule limitations of the current project, the bearings were selected from the shelf to fit the standard GL&V housings. In order to protect the bearings from excessive overheating, GL&V design engineers have selected the special high-temperature lubricant DuPont Krytox that has a dropping point (thickener melting point) of 325°C (617°F). Special thickener formulations provide useful lubrication up to 371°C–399°C (700°F–750°F), or higher with re-lubrication, which worked perfectly with industrial bearings that operate in a high temperature environment. Figure 8 illustrates the selected bearings and the housing employed.

![Figure 8. GFDD bearing (a) and bearing housing (b) employed for the full-scale unit](Photo Credit: Gas Technology Institute)

The GFDD design assumed introduction of the premixed flow of gaseous fuel and combustion air from the opposite side of the combustion product exhaust (Figure 9). To provide the simplified waste heat recuperation, the combustible mixture entering the GFDD is routed through the internal journal and is distributed by the flex feeders; in this way, the combustible mixture was preheated by the combustion product escaping from the drum. Such a simple recuperative approach allows preheating the fuel/air mixture to approximately 148°C (300°F) and significantly reduces the heat losses with the flue gas.
Both journals and drum sides were treated with the special Jet-Hot coating to reduce the heat losses to the environment. Because of its low emissivity and insulating effect, this coating creates a thermal barrier to protect journals—inside and out—while reducing heat transfer into the drum. For more details, please visit [http://www.jet-hot.com/](http://www.jet-hot.com/).

The drum shell was manufactured from the cast iron traditionally used for this type of drum. The shell thickness of 1.625 inches was determined from the standard engineering calculations to secure drum integrity at the operating rotation speed and temperature level. Figure 10 illustrates the GFDD mounted on the frame with a chain-sprocket driving system prior to final assembly for the pre-shipment test.

Figure 9. Introduction of the air/gas mixture into the GFDD system
Photo credit: Gas Technology Institute
To promote the combustion products evacuation from the GFDD, the exhaust fan was implemented into the exhaust train as shown in Figure 11.

Figure 11. (a) GFDD exhaust and ID fan for combustion products evacuation; (b) top view; (c) side view
Photo Credit: Gas Technology Institute
To secure the spark ignition by delivering 10,000 volts to the igniter installed at the tip of the ribbon burner, the ignition wire was routed through the drum construction inside the stainless steel housing with intermediate high-temperature ceramic bushings. Figure 12 illustrates the spark ignition and flame-sensing system installed at the GFDD full-scale trial unit.

To eliminate the affect of high voltage and ensure the flame propagated across the entire length of the ribbon, spark igniters were installed at one side of the burner while the flame-sensing electrodes were installed at the opposite side of the burner. To ensure reliable flame-sensing, the system employs two flame rods as well as igniters, and the operator has the option of selecting the individual sensor and igniter.

Because the GFDD operates in dusty environments, NEPA and NFPA requirements were taken into consideration and appropriate components and enclosures were implemented into the design.

The set of fabrication drawings, schemes, and piping and instrumentation diagrams (Appendix B) completed the full-scale design development of the GFDD.

2.2. Laboratory Thermal Processing
To identify the initial benchmark for the full-scale GFDD operation, in-house thermal processing of the generic product was performed. Figure 13 illustrates the laboratory setup that was used for the thermal processing of the product, per Table 1.
Figure 13. Laboratory thermal processing
Photo credit: Gas Technology Institute

Table 1. Test parameters for laboratory processing

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<th>Hot Surface Temperature, °F</th>
<th>Processing Time, second</th>
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<td>320, 360, 400, 450, 500</td>
<td>10, 25, 50, 75 (20, 50, 80)</td>
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Source: Gas Technology Institute

The effect of mixing the thermally processed product with non-processed product on the overall color scan was also evaluated. The proportions tested were 25/75 percent, 50/50 percent, and 75/25 percent.

During the course of the laboratory evaluation for plant quality control (color scan), 186 samples were produced (Figure 14).
A color scan was performed using the Agtron M-45 surface color scanner calibrated according to the certified procedure approved by the plant management (Figure 15). The results of the evaluation are presented in Appendix C.

Preliminary analysis of the processed powder samples allowed the project team to generate the families of curves, clearly indicating the dependence of the product quality on the temperature level and processing time.

Figure 16 presents examples of the preliminary plots for the powder scans. The product quality range is about 69-75 percent (onion powder) depending on the customer’s specifications.
Examples of the preliminary product processing results for temperature levels of 400°F and 450°F are presented in Figure 17.

From the obtained data the operator could select initial conditions for further tuning the GFDD system to optimized and efficient operation.

2.3. Full-Scale System: Field Engineering and Installation

Upon completion of the series of pre-shipment tests, all the components were delivered to the participating food processing plant for final assembly and installation. The host site performed extensive field engineering and provided the qualified space and required utilities, including the air humidity control and duct collecting unit. The appropriate construction permits were obtained by the host.

Prior to shipping the partially pre-assembled GFDD unit to the California host site, the system was extensively evaluated at the manufacturing facility. The facility performed a functioning check of all mechanical and electrical components as well as a check of the combustion...
performance of the burner-controls system. Figure 18 illustrates the partially assembled GFDD at the GL&V facility in Hudson Falls, New York.

![GFDD assembly at GL&V facility in Hudson Falls, NY: a – drum on the frame ready for function check; b – GFDD system pre-assembled and ready for shipment to the plant](Photo Credit: Gas Technology Institute)

The GFDD system was installed in a specially designed framework that could accommodate a second GFDD, if production increases so require. The product handling equipment was provided by the host as in-kind contribution to the project and was installed by local contractors. The following series of photographs is included to illustrate the progress of GFDD installation.

![GFDD installed at the plant](Photo Credit: Gas Technology Institute)  
![System installation in progress](Photo Credit: Gas Technology Institute)
A number of ancillary units were installed for environmental control and product handling.

Figures 19–21 illustrate the humidifier, dust collector, product loader, sifter, and final product discharge units.
Figure 20. Product loading: a – dumper; b – feeder
Photo Credit: Gas Technology Institute

Figure 21. Product handling: a – sifter; b – transportation; c – discharge
Photo Credit: Gas Technology Institute
The detailed operating/installation manual for the GFDD system is presented in Appendix D. The maintenance procedure is to be developed by plant operations personnel in compliance and coordination with the operating manual.

### 2.4. Combustion Controls and Main Control Panels

The combustion control system was developed by FBC based on the Allen-Bradley Industrial Computing system. The system is used for GFDD surface temperature control integrated with the product feed, rotation speed, and exhaust fan capacity. Below are the selected screens to be used by the GFDD operator.

The overview screen (Figure 22) indicates the overall picture of the GFDD, including rotation speed, surface temperature distribution across the drum, as well as setpoint temperature and average value of the resistance temperature detector (RTD) measurements. From this screen the operator could start/stop drum rotation.

![Figure 22. System Overview Display](source: Flynn Burner Corporation)

The combustion system (burner) screen (Figure 23) indicates firing rate along with exhaust fan capacity and actual average temperature of the drum. It also indicates manual or automatic operations and specifies the igniter and sensor that are being used. Using this screen, the operator is able to light the burner by initiating the purging/ignition sequence, and to immediately shutdown the system, if necessary. The operator also can change the igniter or sensor in case of failure.
The engineering screen (Figure 24) allows the operator to configure the burner and set the GFDD operating temperature and firing rate. It also allows the operation of the induced draft (ID) fan in manual mode.

The operator has access to several more screens that enable observation of operating procedures such as the combustion sequence indicated above (Figure 25).
The detailed manual of the GFDD combustion system operation is presented in Appendix E. The GFDD combustion control system was successfully integrated with the main control system. The main control panel shown in Figure 26 provides overall GFDD operation control and product handling equipment. The main control panel was developed by plant personnel and is not further discussed in this report.

Figure 26. GFDD combustion control (a); main control cabinet (b); process overview screen (c)
Photo Credit: Gas Technology Institute
3.0  Project Results: GFDD Performance Evaluation

The GFDD system was successfully installed as indicated in Figure 27 and fired at different operating conditions so the combustion system could be adjusted for the best performance. The system characterization procedure was developed (Appendix F) and currently is under implementation for transferring the GFDD system to the plant operating personnel.

Upon completed shakedown, the system performance was evaluated in an operating range of setpoint temperature (65°C-148°C, or 150°F–300°F) at the selected drum rotation speed. Figure 28 illustrates 10 hours of evaluation performance without product application.
All the measurements were made at a drum speed of three revolutions per minute, a doctor blade load of 15 pounds per square inch, and no product application. It is remarkable that as higher setpoint temperature as lower temperature peak while the drum is preheating to setpoint, so the low firing rate value (currently set as 3” water column) should be determined during the product run to compensate ambient losses and product load. Moreover, as higher setpoint temperature level as lower deviation of the temperature readings over the average value due to better heat distribution uniformity, so steady-state conditions are expected after the drum preheating period. The surface temperature uniformity across the drum that is measured by RTD is more scattered than measured by contact thermocouple, so in order to improve the temperature profile the doctor blade has to be adjusted more carefully across the drum.

Figure 29 demonstrates the GFDD surface temperature cycling at different setpoint temperature levels.
Figure 29. Comparison of RTD readings and drum surface measurements at different setpoint temperatures
Source: Gas Technology Institute
It was observed that as higher setpoint temperature level as large difference between the RTD and drum readings (see Figure 30), so such a correlation should be established during the product runs (per product scan).

![Graph showing correlation between RTD and drum readings](image)

**Figure 30. Correlation of RTD readings and drum surface temperature**  
Source: Gas Technology Institute

The GFDD combustion system provides a pre-mixed low emission operation. The quality of natural gas combustion was evaluated by both visual observation and emissions measurements. The combustion system logic was designed to operate the system in such a way that while approaching the setpoint temperature the firing rate slows down from high value to low value depending on the heating rate, and upon reaching a setpoint temperature the burner is ceased until the actual temperature reading will not drop two degrees below the setpoint value. Then the burner is re-ignited at a low firing rate to heat the drum to setpoint temperature again. The “on and off” operation of the burner indicated that at a low setpoint temperature level the GFDD operates a shorter time than at a high setpoint temperature level. However, even at high setpoint values the GFDD system produces less environmental impact than continuously operating systems. Figure 31 records the visual observation of the ribbon flame at high firing and low firing operations.
The composition of the exhaust gas was measured during the pre-shipment factory acceptance test and after complete installation in the field. Both times the carbon dioxide (CO2) and NOx emissions did not exceed California regulation limits for such installations.

The emission measurements were performed by the GTI team using the state-of-the-art portable gas analyzer HORIBA P-250. Figure 32 illustrates the sampling port, analytical equipment, and measurement screen. The GTI measurements were confirmed via independent measurement by plant environmental contractors (Blue Sky Environmental Inc.) sampling the flue gas from the same port at the GFDD exhaust. For the gas analysis, Blue Sky Environmental Inc. used the traditional set of certified analytical equipment, Thermal Electron and Rosemont brands. Through the set of emissions measurement to prove the repeatability of the data, the following ranges of exhaust emissions were received for the steady state GFDD operation (corrected at 3% oxygen):

- CO2: 15-25 parts per million by volume (vppm)
- NOx: 30-50 vppm
- Total Hydrocarbons: < 5 vppm
 Obtained results clearly indicate a low environmental impact compared to a steam generation facility that produces steam for traditional steam-heated drums.
4.0 Conclusions and Recommendations

The overall aim of this project was to apply energy-saving and low-emission technology to a food processing application and demonstrate the benefits at a California-based industrial facility. The GFDD system was successfully developed and installed at a major California-based food processing plant and evaluated in a wide range of operating temperatures. The anticipated performance benefits were proven along with the low emissions operation.

4.1. Commercialization Potential

GTI, together with minor subcontractor Bedrosian & Associates (a Disabled Veteran Business Enterprise [DVBE]), identified a list of potential food processors that might benefit from GFDD technology. Bedrosian & Associates conducted a national search and contacted several hundred food processing plants to explore interest in GFDD and to initiate beneficial working contacts. A brief report on these efforts is presented in Appendix G.

4.2. Recommendations

The host site will tune up the system per product specifications and continue monitoring the GFDD performance in a product application environment. GTI, jointly with GL&V, will continue marketing this energy-saving technology for California food processors per the list of potentially interested food processors developed by Bedrosian & Associates, and will initiate the technology commercialization process nationwide.

4.3. Benefits to California

Evaluation of the installed single drum system at the participating food processing site clearly demonstrated the following major benefits:

- Increased production capacity over the traditional double-drum steam-heated system currently employed by the industry.
- Low emissions produced by the internal combustion system with a turndown ratio 5:1 that meets California regulations.
- The possibility of varying the drum rotation speed and surface temperature for optimal production adjustment when processing products with different specifications.
- The possibility of using different gaseous fuels such as natural gas, liquefied petroleum gas, syngas, landfill gas, etc.

Successful implementation of gas-fired drum dryer technology throughout the qualified California food processing applications will result in significant energy savings and cost within the state’s industrial market.
5.0 References


6.0 Glossary of Terms

CO2  Carbon dioxide
DVBE  Disabled Veteran Business Enterprise
Doctor blade  A scraper device used to remove processed product from a drum dryer
FBC  Flynn Burner Corporation, the combustion equipment manufacturer
GFDD  Gas-Fired Drum Dryer
GL&V  Groupe Lapierrier & Verreault USA Inc., the drum dryer manufacturer and potential technology licensee
GTI  Gas Technology Institute, the technology developer
ID fan  Induced draft fan
MMBtu  Million British thermal units
NEPA  National Environmental Policy Act
NFPA  National Fire Protection Association
NOx  Nitrogen oxides
RTD  Resistance temperature detector
TBtu  Trillion British thermal units
THC  Total hydrocarbons
Vppm  Parts per million by volume
WC  Water column
Appendix

Appendix A:
Computational Fluid Dynamics Modeling Results

Appendix B:
Design Drawings, Sketches, Piping and Instrumentation Diagrams

Appendix C:
Powder Scan Results

Appendix D:
Operating Manual (Groupe Laperrier & Verreault USA Inc.)

Appendix E:
Combustion Controls Manual (Flynn Burner Corporation)

Appendix F:
System Characterization Procedure

Appendix G:
Bedrosian & Associates (DVBE) Report on Gas-Fired Drum Dryer Marketing Calls
Appendix A: Computational Fluid Dynamics Modeling Results
0.5 MMbtu/hr

Distance between burner and drum is 2 3/4”.

Partition - 45 degree
1 MMBtu/hr

Distance between burner and drum is 2 3/4”.

Partition - 45 degree
1 MMBtu/hr
Distance between burner and drum is 2 3/4".
Partition - 90 degree
Appendix B: Design Drawings, Sketches, Piping and Instrumentation Diagrams
DOCTOR PUMP DIAGRAM

OPERATION MANUAL FOR DOCTOR LOADING
REFERENCE PU VSP PSL ADDR Diagram located in
LENGTH FROM FRONT TO BACK SIDE
TIME LENGTH FROM TE TO COUNTER TO BE EQUAL

NOTES:

1. PUMP TUBE UNION TUBE ALL PARTS SWACOLOCK #SS-810-3.5
2. CONNECTOR TUBE 3/4 INCH TO MAKE PUMP SWACOLOCK #SS-810-1.5 X 12.5 X 75
3. VALVE MATERIAL LOCKOUT PUMP SWACOLOCK #SS-810-1.5 X 75
4. VALVE MATERIAL LOCKOUT 3 PVDF 2 POSN-LOCKOUT #733-44-PM 5 PVDF 3 PM 614-44-PM 5 PVDF
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Appendix D: Operating Manual (Groupe Laperrier & Verreault USA Inc.)
### MACHINE DATA

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INTRODUCTION AND CONTACTS

The contents of this manual do not supersede the job contract and/or engineering drawings supplied. If questions arise as to areas of responsibility for installing and / or supplying, please refer to the job contract, engineering drawings provided, and contact:

GL&V USA Inc.
27 Allen Street
Hudson Falls, New York, 12839
Phone (518) 747-2444
Fax (518) 747-1320

This manual has been specifically prepared to provide the reader with information to comprehend, install, operate, and maintain this equipment. The information is a guide for the care and operation of this machine. Under no circumstances are the contents of this manual to be considered the only way to perform an operation, however, it is to be used as a guide to reach the ultimate goal of safe, trouble free production. The training and instruction of personnel in the safe method of operation is the user/employer’s responsibility. Qualified instructors along with this manual and experience should be used for the training of new operators. Periodic refresher sessions should also be held to review the safety procedures and any contemplated operation procedural changes. As personnel become more familiar with the equipment, procedures, by necessity, will be improved and revised to include more efficient and safe operation. Safety during installation, operation, and maintenance of this equipment is the responsibility of the user. GL&V cannot address every conceivable safety problem for the life of this equipment. Common sense and good industrial practices should be enforced.

Machine areas that do require special procedures are carefully detailed to provide sufficient information. Please distribute this manual to all personnel responsible for installation, operation, and maintenance of the machinery.

Please refer to the data on the machine elevation drawing and our sales order number for rapid service.
The quality of the product being processed on this machine is highly dependent upon the accuracy of installation. The recommended tolerances and techniques of installation described in this manual will insure that you manufacture the best product possible. Please consult the certified drawings for specific information about parts and details.

Competent technical service personnel can apply these techniques and provide guidance in achieving a quality installation. Your purchase order and our sales proposal will indicate if technical startup services are included with the equipment. If startup assistance is included, coordinate with GL&V to schedule the technical service. If startup assistance is not included, technical startup services are available from GL&V, through the technical service department. These services are strongly recommended.

MODIFICATIONS OR RELOCATION OF EQUIPMENT

The equipment supplied is manufactured according to the negotiated specifications. However, during the life of the equipment, the user may desire changes and/or modifications. We recognize that these modifications will take place, and thus we are asking your assistance in keeping our records up to date. By doing so, you will insure continued accurate service when ordering parts and / or requesting assistance.

If you’re contemplating modifications and / or a re-location to another plant, please contact us so that we may:

1. Offer assistance through engineering services.
2. Update our records to reflect the latest design.
3. Advise on safety considerations.
4. Review with you possible existing designs that you may want to consider using.
5. Submit appropriate proposals, complete with prices and deliveries.
6. GL&V can offer assistance in installation, start up, operator training, and maintenance programming for your new equipment. GL&V encourages you to discuss your requirements with our customer service department.
GENERAL SAFETY FOR DRYER SECTION

At GL&V, we feel that our customer's personal safety is as important as the successful operation of our equipment. The following safety tips have been compiled to help mill employees understand the potential danger areas associated with installation, operation, and maintenance of the dryer section. These safety tips are offered as a supplement to the mill safety program and are not intended to supersede a more stringent existing safety policy.

EMPLOYEE TRAINING

1. All personnel working around the equipment must be completely familiar with the function of the equipment.

2. All personnel should understand the action of the components that move and could present a hazard if not respected and used in a safe manner.

3. All personnel should be made aware of all moving or rotating components of the equipment that cause possible entanglement.

4. All personnel should be made aware of the high temperatures associated with the dryer section and the possibility of burns.

5. All clothing worn by the operating personnel should be close fitting but must permit freedom of movement.

6. Personnel should understand the control system in order to be able to deactivate machinery as quickly as possible in case of an emergency.

WORK AREA

1. The working area must be well lighted and should be kept clean and clear of obstructions.

2. Steps and walkways should be kept free from all foreign articles.

3. The floor and surrounding surfaces should be free from spilled oil, grease and water.
4. All exposed soleplates should be covered with a non-skid surface.

5. All guards and handrails should be in position during operation.

INSTALLATION SAFETY SUGGESTIONS

During the construction and installation phases, the area and nature of the work can lead to hazardous conditions.

1. Only qualified people, such as millwrights, electricians, etc., should be in the construction area. All others should be kept away.

2. Proper and safe equipment is required to be on hand to handle the many heavy pieces of machinery. Make sure that all of the safety features are checked and verified before using them.

3. Follow safe lifting practices when installing machine components. Remember that pieces should be bolted in place before removing the lifting device. Stay within the load rating of all cranes, hoists, cables, chains, slings, etc.

4. Adequate personnel protection such as safety shoes, glasses, hard hats, and gloves should be worn at all times. Special personnel protection, as may be required by the job (welder’s helmets, painter’s respiratory masks, etc.) should be available, in good condition and used by the installers.

5. Adhere to all codes governing the safe and proper installation of the equipment.

6. Keep the work areas clean. Do not allow waste materials to accumulate. Keep the work areas reasonably well illuminated.

7. Only bring material that is necessary into the construction area. Keep all other neatly stored out of the area.

8. Observe local fire department regulations and fire-prevention recommendations.

9. Always check to be sure personnel and equipment are clear of the area before starting any equipment.
10. Do not try to defeat any safety devices.

11. Do not move equipment overhead of any personnel until all personnel have moved to a safe location.

**OPERATIONAL SAFETY SUGGESTIONS**

Paper machine operation is comprised of different functions that should be thoroughly known and understood by personnel working on the machine. When they are known, it is easier to understand the safety risks that exist on the paper machine. It is of primary importance that personnel are properly trained to perform their tasks.

1. Do not operate the machinery unless authorized and trained to do so. Tasks that are not frequently performed require well-trained personnel who are aware of the proper working methods. These tasks include felt changes, roll changes, repair work on the machine. If an operator is unfamiliar with the operation of particular pieces of equipment, he must obtain the proper instructions and training prior to attempting to operate equipment.

2. The high temperatures that are present create an additional risk due to hot surfaces and the resultant fire hazard.

3. Do not wear loose clothing when operating the gas fired paper dryer. Loose clothing can be caught in rotating equipment.

4. There are numerous nip points. Keep clear of all nip points when the machine is in operation.

5. Operators must be familiar with the risk factors involved in operating and working around equipment having high temperatures.
MAINTENANCE SAFETY SUGGESTIONS

The following suggestions are offered to protect the personnel that perform maintenance on machinery.

1. The initial step to be taken before any work is done on any machinery is to ensure that the machinery will not be started accidentally. That is best accomplished by having the mechanic performing the maintenance lock-out and tag-out the power disconnect switch for the component being worked on. This lockout also applies to pneumatic and hydraulic devices. These devices can also store energy that can be released at any time. Ensure all pneumatic and hydraulic devices are locked so that the release of this energy will not cause damage or injury. Mill site procedures should be followed for lock-out and tag-out.

2. High dryer surface temperatures can cause severe burns. If work is to be performed directly on or around dryers, a proper amount of time should be allowed for the dryer to cool down. Proper cool down procedures should be followed when shutting the dryer section down. It will take several hours or days for all the dryer to cool down, however, the process can be expedited using cooling fans.

3. It is sometimes necessary to enter dryer for inspection, clean up or repairs. The inside of a dryer must be considered as a confined space environment.

4. Manholes must be properly maintained to eliminate sharp edges.
SAFETY PARTICULAR TO GAS FIRED PAPER DRYER

WARNING!!! Dryers must not be directly sprayed or washed with cold water. Such extreme thermal differences could crack the dryer shell or heads causing catastrophic failure.
UNPACKING AND STORAGE

GL&V PREPARATION FOR SHIPMENT

Equipment provided by GL&V is pre-assembled prior to shipment. Our sales proposal will indicate the amount of pre-assembly completed. The gas fired paper dryer is assembled complete.

For shipping purposes, some machine sections must be disassembled.

Prior to disassembly the frames are match marked.

The disassembled machine sections are boxed, crated, bundled, shipped loose, or mounted on skids for shipment.

As much as possible, a component machine section is normally packaged together, even though it has been broken down for shipping.

Loose items, such as columns, cross ties and modular framing subsections etc. are generally non-packaged items.
RECEIVING

The method of receiving and storing equipment from arrival to installation can expedite or retard the orderly progression of installation. Store all equipment in a protected and controlled area that can be secured to prevent access by unauthorized people.

As each shipment arrives, carefully inspect it for damage that may have occurred during transit. Of particular importance for inspection are instrument panels and consoles. Internal inspection of these cabinets is required. Dismantling of the shipping container is necessary to accomplish this, but it is imperative that protection of the cabinets be provided immediately after the conclusion of the inspection. If damage has occurred, report it immediately to the carrier and advise GL&V. Please refer to the information on the manifest when reporting missing or damaged equipment.

After checking the shipment against the manifest, move the equipment to the storage area. We suggest that the storage area be sectioned off and a record made where each piece of equipment is placed. This will provide efficient retrieval of desired parts. A responsible clerk should supervise records and sign out parts received, and parts sent to immediate job site for permanent assembly.

The containers are carefully made to facilitate moving by crane and/or fork truck.

When receiving dryers, they should be carefully checked for damage during shipping. If any damage is found, immediately alert GL&V and the carrier.

GL&V dryers are normally covered with a coating to protect against corrosion and then paper wrapped and skidded for shipment. The protective coating for normal storage is a combustible liquid called Rust Veto 342. For long-term storage, Rust Veto 344 protective coating is used. This coating is similar to Rust Veto 342 except that it is darker and thicker. For technical information and other data on this protective coating refer to the Manufacturers Safety Data Sheets that are included in this manual.

To remove these coatings use TURPENTINE OR KEROSENE.
Chrome plated, chrome/teflon or Teflon coated dryers need special packaging to protect the expensive coatings. Therefore, these dryers come with an extra layer of wood slats around the entire face of the shell. Also, the dryers come on special skids, which attach to the journals only.

All other machined surfaces are coated with a rust inhibitor that is easily removed, at installation, with a solvent that is approved for use by the installation site supervisory personnel.

HANDLING OF DRYERS

A label showing the correct and incorrect finished dryer handling is included on the dryer paper wrapping. It is also shown below.

![Finished Dryer Handling Methods Diagram]

Finished Dryer Handling Methods

Never use any lifting method that could damage the finished face or journals of the dryer. The preferred method of lifting is with an overhead crane. A fork truck can be used as long as the proper handling methods are observed.
UNPACKING

As a piece of equipment is needed, move it to the job site before unpacking. If small or individual pieces are needed, remove them from their container, leaving the others in the protective container.

Carefully disassemble the container, removing all outside pieces. Inspect how the components were secured to the bottom part of the container.

Remove hold down bands and bolts. CAUTION: Some components are supported and may move when their respective hold down ties are released. Use extra caution around these items. After all of the tie downs have been removed, move the component to its prescribed position.

LONG TERM STORAGE

In the event that you must store the equipment in excess of 30 days, we offer the following as a guide for its protection until such time as installation commences. Generally, inside storage is the best, but outside storage can be accomplished by building a weatherproof shelter.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dryers</td>
<td>The recommended storage area for dryers is a dry, low humidity, dust-free storage room. The wooden skid used for transportation can be used for storage purposes as well. If dryers have to be stored outside, take paper wrapping off the dryers to prevent creation of water pockets between paper and dryer shell. Add protective coating material to all surfaces that can have contact with water. Occasionally check surfaces for possible scratches and/or spots on the protective coating and re-coat if needed.</td>
</tr>
<tr>
<td>Hydraulic Systems</td>
<td>Fill system with a rust inhibited oil. Circulate oil through the system and seal.</td>
</tr>
<tr>
<td>Unpainted Ferrous Surfaces</td>
<td>Coat with Cosmoline or equal.</td>
</tr>
<tr>
<td>Openings</td>
<td>Seal with Cosmoline-saturated paper or equal. Use, when appropriate, plastic pipe plugs or caps.</td>
</tr>
<tr>
<td><strong>Couplings</strong></td>
<td>Pack with grease and coat outside with Cosmoline or equal.</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Exposed Threads</strong></td>
<td>Coat with FELPRO C5A or equal.</td>
</tr>
<tr>
<td><strong>Machine Assemblies</strong></td>
<td>Insure adequate support under all machine bases.</td>
</tr>
<tr>
<td><strong>Instruments</strong></td>
<td>Remove from machine, tag instrument and location. Seal openings on machine and pack instruments in a crate with a desiccant.</td>
</tr>
<tr>
<td><strong>Control Panels</strong></td>
<td>Remove any plastic airtight coverings that were used for shipping. DO NOT STORE OUTSIDE. Tighten all terminals. Seal all openings with a desiccant inside. Check desiccant monthly.</td>
</tr>
</tbody>
</table>

At the conclusion of the storage period, equipment may be cleaned and installed during the normal installation program. Bearings that were grease packed for storage should have their drain plug removed, where provided, and the bearing purged with new lubricant. You may also leave the plug removed during the first few hours of operation to insure complete purging and to relieve any excess grease that may have been put in. Flush protective oils from all lines, drain gear reducers, and refill.
SITE PREPARATION AND INSTALLATION OF SOLEPLATES
(THIS SECTION IS PROVIDED FOR REFERENCE ONLY
NO SOLE PLATES ARE PROVIDED)

1. GL&V can assume no responsibility for the type of site construction and/or preparation required for the installation of the machinery.

2. Points of hold down and typical anchoring methods are provided in this section.

3. Live load design for the dryer section should be based on 150% of the dead load.

4. All anchor bolts, washers, nuts, and pipe sleeves to be furnished complete by customer. Competent engineers should do foundation and anchor bolt design.

5. All anchor bolts are suggested to be 1-inch diameter and the threaded portion should project 1-inch minimum above sole plate. The threaded portion of the anchor bolt should be approximately five inches long.

6. Dimensional information shown on the following diagrams represents requirements above rough concrete elevation. Ideally, the bottom of each soleplate should be located approximately two inches above the rough supporting concrete.

7. Three brass plugs in the operating floor ideally establish the centerline of the paper machine. A plug should be located at each extreme end of the machine and the third plug at the approximate center of the machine. Elevation control is ideally maintained by establishing "bench plates" to +/- 0.000" intermittently along the length of the machine.
SOLE PLATE INFORMATION

Foundation plate dimensional information is shown below. For specific dimensional information about this machine see elevation drawings.
This procedure is not proprietary and can be provided to customers.
FOUNDATION CONSIDERATIONS

IF FOUNDATION BOLTS PROTRUDE ABOVE PLATE, CUT OFF FLUSH WITH TOP OF PLATE AND FILL RECESS WITH GROUT.

LEVELING SCREW .63 - 1.1 X 3.00 LONG SOCKET SET SCREW

LEVELING WASHER APPLY POR-ROK CEMENT OR EQUAL UNDER WASHER

EXPOSED GROUT CONTAINING METALLIC PARTICLES SUSCEPTIBLE TO CORROSION SHALL BE SEALED WITH EPOXY PAINT.

TYPICAL SOLEPLATE HOLE AND C’HORE FOR FOUNDATION BOLTING: ø1.13 THRU C’HORE ø3.25 X 1.13 DP.

FOUNDATION ANCHOR BOLTS (1.00 RECOMMENDED), WASHERS, NUTS AND PIPE SLEEVES BY CUSTOMER. METHOD OF ATTACHMENT BY CUSTOMER. EXPANSION BOLTS OR OTHER QUICK INSERTION BOLTS ARE NOT RECOMMENDED FOR SECURING OF PAPER MILL MACHINERY.
INSTALLATION OF SOLEPLATES

These tolerances are to establish general guidelines for those involved in scheduling and executing the installation of the machine. The customer’s installation contractor and/or agents are responsible for maintaining actual tolerances during the installation of this machine.

All grout design and placement of grout is the responsibility of the customer. GL&V has no authority to specify or recommend grout mix or add-mixes. Deviations from standard grouting practice, such as hollows, could result in structural failure. The above remarks apply particularly to repair/reinstallation/replacement of existing plates, which are to be overlaid by another row of plates.

SETTING SOLEPLATES

The sole plates can now be placed over the anchor bolts as called for on the drawing and held in place with a nut and washer.

The first sole plate installed must be located from the original building center and square lines, also sole plates must be located with proper clearance between sole plates as shown on GL&V typical foundation drawing, as measured from the finished surface. Plates can now be rough leveled and aligned throughout the entire machine.
SOLEPLATE TOLERANCES

Soleplate readings should be taken per the following sketch.

Target readings should be taken between A-B, C-D, E-F

Level Readings should be taken along dotted lines

a) Sole plates must be level in the machine direction within 0.005 inches.
   1) A maximum deviation of 0.003 inches in any one foot of length and,
   2) A maximum accumulation of 0.020 inches per 100 feet and,
   3) A total maximum deviation from machine elevation of +/- 0.060 inches in any 100 feet of length.
b) A sole plate must be level in the cross machine direction within .0005 inches per 12 inches of sole plate width.

![Diagram showing levelness of sole plate](image)

0.0005 PER 12" SOLE PLATE WIDTH

![Diagram showing levelness](image)

0.0005" PER 12" MACHINE WIDTH
0.009" MAX

0.009 inches maximum deviation.

Machine width for this measurement is from outside of sole plates.

c) Front side and back side sole plates must be level or set to design elevation difference within 0.0005 inches per foot of machine width but not more than 0.009 inches maximum deviation.
SOLE PLATE CENTER AND SQUARE LINE LAYOUT

A. Machine direction centerlines (on sole plates) should be accurate to and parallel with the machine centerlines and each other within 0.015 inches. If proper instrumentation is available, the checking of these centerlines can be done to much greater accuracy than that given above.

B. When such instrumentation is not available it will be necessary to check the square lines by trammel method. Extreme care must be exercised when checking square lines where the distance involved between sole plates preclude the use of a trammel. In this case, tape measurements must be used. It is suggested that as long a trammel as possible be used to swing two arcs equidistant and intersecting the centerline from the intersection of the square and the centerline, dimension “X” and “X”. Tape measurements can now be made from the intersection of the square line and centerline on the opposite sole plate (Point “CP) to the intersection of the two trammel arcs and the centerline (Points “A” and “B”). Where possible, the trammel length (X+X) should be equal to the distance between the centerlines making a 45-degree measurement. The difference between the two tape dimensions (AC and BC) should not exceed 1/64 inch.

![Diagram of SOLE PLATE CENTER AND SQUARE LINE LAYOUT]
C. The diagonals (AB and CD, or DE and BF, etc.) must be equal within 1/64 inch. S

D. All center and square lines must be scribed and should be center punched on the sole plates every 2 to 3 feet. This method of punching should produce a lasting record for future machine alignment checks. It is strongly recommended that centerlines and reference points be identified by metal stampings and cross-referenced on the foundation drawing. This reduces the chance of error when having the quantity of reference points that are involved during installation.

Layout and checking of centerlines must be carried out accurately. If any appreciable discrepancies are allowed to accumulate, considerable problems will be encountered at a later date trying to bring sections of the machine back into alignment.

Original benchmarks, plugs for centerlines, cross machine centerlines and other original reference marks should be protected in a manner such that they will out live the machine. Future additions or changes of equipment will be more easily made if reference points are available.
Layout measurements should be made using the same steel tape on all measurements. Tape should be tensioned with the use of a spring scale to a load of 15 pounds on a 100-foot tape. The effect of extreme temperature will produce serious errors in measurements and it is necessary that this difference be compensated. Whenever possible, measurements should be made by rechecking previous days layout before starting your new layout. Optical equipment, when used, should be checked and verified daily by the engineer and/or technicians for calibration.

Record sole plate elevations and levels. Elevation readings should be taken at each pair of hold down bolts as well as cross plate elevations. The readings should be recorded on the machine foundation drawing, together with such information as type of instrument used, location of readings and date. Repeat procedure for both tending side and drive side.

GROUTING SOLEPLATES

The supporting concrete should be roughed up to remove fines and weak material in preparation for grouting of the soleplate. The foundation and the anchor bolt sleeves should be cleaned and free of all undesirable foreign materials before grouting.

When the soleplate is in the correct position and is ready to be leveled, the leveling washers should be fixed to the supporting concrete. Shims may be used under the leveling washers to build up height if needed. In this case, the shims must also be fixed to the supporting concrete. One-quarter inch of thread on the leveling screw should project through the soleplate for final adjustment. After the soleplate is leveled and washers are in position, tighten all anchor bolts. The leveling screws are for adjusting the soleplate only. Leveling screws should never be used alone for support during grouting. Recheck the soleplates carefully for final level and position.

A non-shrink grouting is recommended for grouting paper machine soleplates. Dry pack grout is not recommended. The handling and mixture of any non-shrink grout should follow the specific instructions of the manufacturer.

The form material used to contain the group should be strong enough to withstand the pressure of the grout. Allow six inches between the form and soleplate to work grout.
Saturate the foundation with water before grouting. Grout anchor bolts first. Use a wire to work the grout down into the anchor bolt sleeves. Place the grout as quickly and continuously as possible to prevent over working.

Paint exposed grout surfaces containing metallic particles with epoxy paint.

Allow grout to completely cure before continuing with installation.

After soleplates have been reinstalled/repaired as required then grouted and checked, all anchor bolts extending above the bottom sole plate layer must be cut off .12” below the top of the plate. Fill anchor pocket voids around anchor bolts with grout. Metalized epoxy can be substituted for grout when filling pockets. Excessive filler should be removed flush and smooth with the top of the sole plate.
DRYER FRAMING

The framework for this dryer system is designed to support the dryers and related equipment as shown on the elevation drawings. The framework is constructed of fabricated steel, The framework is designed specifically for this application, any alteration or modification to the framework should be first approved by GL&V.

DRYER FRAME INSTALLATION

The dryer frames must be installed correctly in proper alignment to ensure ease of installation of any accessory equipment that may attach to the dryer frames. This applies to any rolls in particular. Any misalignment may cause the dryer felts to track incorrectly. The alignment tolerances for dryer frames are given below:

1. Centerline of dryer frame to centerline of machine must be maintained to +/- 0.015 inches.

2. Horizontal machined surfaces must be level to +/- .001 inches per foot.

3. Elevation difference of matching machined frames from Tending Side to Drive Side must be held to +/- .010 inches.
Properly torque mounting hardware per the following table.

<table>
<thead>
<tr>
<th>Nominal Diameter (inches)</th>
<th>Threads per inch</th>
<th>Unlubricated</th>
<th>Plated</th>
<th>Lubricated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Torque-</td>
<td>Torque-</td>
<td>Torque-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAE 2 (ft-lbs)</td>
<td>SAE 5 (ft-lbs)</td>
<td>SAE 8 (ft-lbs)</td>
</tr>
<tr>
<td>0.25</td>
<td>20</td>
<td>5</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>0.3125</td>
<td>18</td>
<td>11</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>0.375</td>
<td>16</td>
<td>20</td>
<td>31</td>
<td>44</td>
</tr>
<tr>
<td>0.4375</td>
<td>14</td>
<td>32</td>
<td>49</td>
<td>70</td>
</tr>
<tr>
<td>0.5</td>
<td>13</td>
<td>49</td>
<td>75</td>
<td>106</td>
</tr>
<tr>
<td>0.5625</td>
<td>12</td>
<td>70</td>
<td>109</td>
<td>154</td>
</tr>
<tr>
<td>0.625</td>
<td>11</td>
<td>97</td>
<td>150</td>
<td>212</td>
</tr>
<tr>
<td>0.75</td>
<td>10</td>
<td>172</td>
<td>266</td>
<td>376</td>
</tr>
<tr>
<td>0.875</td>
<td>9</td>
<td>167</td>
<td>430</td>
<td>606</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>250</td>
<td>644</td>
<td>909</td>
</tr>
<tr>
<td>1.125</td>
<td>7</td>
<td>354</td>
<td>794</td>
<td>1288</td>
</tr>
<tr>
<td>1.25</td>
<td>7</td>
<td>500</td>
<td>1120</td>
<td>1817</td>
</tr>
<tr>
<td>1.375</td>
<td>6</td>
<td>655</td>
<td>1469</td>
<td>2382</td>
</tr>
<tr>
<td>1.5</td>
<td>6</td>
<td>869</td>
<td>1949</td>
<td>3161</td>
</tr>
</tbody>
</table>

Note: Lubricated torque values are for SAE 20-SAE 40 oil and can vary greatly depending on the actual lubrication.

**OPERATION AND MAINTENANCE SAFETY CONSIDERATIONS**

Dryer sections are constructed of numerous parts and sub-components. This equipment is automatic and has various nip points. **KEEP ALL BODY PARTS CLEAR OF THE DRYER SECTION UNLESS THE SYSTEM HAS BEEN PROPERLY LOCKED OUT. DO NOT WEAR LOOSE CLOTHING AROUND THE DRYER SECTION.**

The gas fired paper dryer is designed to work at high temperatures. **SEVERE BURNS CAN RESULT FROM CONTACT WITH THE GAS FIRED PAPER DRYER AND ANY NEARBY EQUIPMENT.**
OPERATION AND MAINTENANCE CONSIDERATIONS

The framework is provided primed and finish painted. Periodic cleaning and painting will help reduce corrosion.

All hardware should be tight. Periodically check bolts and other threaded fasteners for the correct torque.
INSTALLATION AND OPERATION OF THE GAS FIRED PAPER DRYER

PREPARATION PRIOR TO MOUNTING BEARINGS

Just before the bearings are to be mounted, remove the protective wrappings.

Large bearings with a thick, greasy, rust preventive coating and bearings that are to be grease or oil lubricated must be washed and dried to remove the protective coatings. The thick, greasy coating on the large bearings will prevent proper bearing mounting and checking of internal radial clearances.

All sizes of bearings using grease lubrication should have the protective coating removed if the bearing is used at very high or very low temperatures since some of the coatings can adversely affect the lubricating properties of the grease used for such extremes of temperature.

On circulating oil lubricated bearings, they should be cleaned with flushing oil to remove and carry off the bearing protective coatings to the oil system's reservoir for filtering and draining prior to the machine's sustained operation.

Before mounting the bearings, check the dimensions of the bearings, the mating shafts and the housings.

Shaft and bearing housing surfaces must be free of dirt, dust, burrs, etc. Clean and/or repair these surfaces before mounting the bearings. Apply a coat of light oil to the bearing journal fit and to the bearing bore.

CYLINDRICAL BORE BEARING MOUNTING

Mount the bearings in a clean, dust-free room.

WARNING!!!
Do not subject the bearings to direct hammer blows when mounting.

Cylindrical bore bearings with light interference fits may be pressed cold onto shafts or into bearing housings.
Cylindrical bore bearings with heavy interference fits require that either the bearing or the bearing housing be heated. If the interference fit is on the shaft, the bearing must be heated. To heat the bearing, use induction heating coils or oil baths - **do not use direct flames and do not heat the bearings beyond 125° C (257° F).** Heating beyond this temperature may change the metal properties and dimensions of the bearings.

Bearing with interference fits in the housings require that the housings be heated. **Do not heat using direct flames.** Heater oil baths are a good way to heat the housings. See manufacturer’s catalog for recommended procedures.

**TAPERED BORE (1:12) BEARING mounting**

Mount the bearings in a clean, dust-free room.

These instructions apply to CK, CCK, CACK and CAK design bearings.

Tapered bore bearings require a relatively tight interference fit between inner rings and shafts. The interference fit expands the inner rings, thereby reducing the internal clearance of the bearings. The reduction of the internal clearance is measured using feeler gauges. Internal clearance is measured before and during drive-up.

With bearing standing on a level surface, use feeler gauges in between the uppermost vertical roller and the outer race of the bearing as follows:

1. Move a feeler gauge carefully in between the uppermost vertical unloaded roller and the outer race with a sawing motion. Do not force the gauge. Do not rotate bearings while measuring. Repeat the procedure until a gauge is found that will barely pass through.

2. Repeat this procedure for the uppermost vertical unloaded roller of the other row and use the average value.

3. Make note of this bench clearance.

4. After measuring the internal clearance, drive bearing up on taper in easy stages until the above noted initial clearance has been reduced by the amount “R” given in the Table 1 for inches or Table 2 for millimeters for the size of bearing being
installed. Note: Minimum permissible final clearance “S” should not be less than that shown in Table 1 or Table 2. This measurement is now taken at the bottom of the bearing since the bearing is now hanging on the dryer journal.
<table>
<thead>
<tr>
<th>BORE DIAMETER (d(\text{mm}))</th>
<th>Reduction in Radial Internal Clearance INCHES</th>
<th>Minimum Permissible Final Clearance in Inches after Mounting Bearings with Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVER</strong></td>
<td><strong>Incl.</strong></td>
<td><strong>Min. - Max.</strong></td>
</tr>
<tr>
<td>50</td>
<td>65</td>
<td>0.0012 - 0.0015</td>
</tr>
<tr>
<td>65</td>
<td>80</td>
<td>0.0015 - 0.0020</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>0.0020 - 0.0025</td>
</tr>
<tr>
<td>100</td>
<td>120</td>
<td>0.0020 - 0.0028</td>
</tr>
<tr>
<td>120</td>
<td>140</td>
<td>0.0025 - 0.0035</td>
</tr>
<tr>
<td>140</td>
<td>160</td>
<td>0.0030 - 0.0040</td>
</tr>
<tr>
<td>160</td>
<td>180</td>
<td>0.0030 - 0.0045</td>
</tr>
<tr>
<td>180</td>
<td>200</td>
<td>0.0035 - 0.0050</td>
</tr>
<tr>
<td>200</td>
<td>225</td>
<td>0.0040 - 0.0055</td>
</tr>
<tr>
<td>225</td>
<td>250</td>
<td>0.0045 - 0.0060</td>
</tr>
<tr>
<td>250</td>
<td>280</td>
<td>0.0045 - 0.0065</td>
</tr>
<tr>
<td><strong>280</strong></td>
<td><strong>315</strong></td>
<td><strong>0.0050 - 0.0075</strong></td>
</tr>
<tr>
<td>315</td>
<td>355</td>
<td>0.0060 - 0.0085</td>
</tr>
<tr>
<td>355</td>
<td>400</td>
<td>0.0065 - 0.0090</td>
</tr>
<tr>
<td>400</td>
<td>450</td>
<td>0.0080 - 0.0105</td>
</tr>
<tr>
<td>450</td>
<td>500</td>
<td>0.0085 - 0.0110</td>
</tr>
<tr>
<td>500</td>
<td>560</td>
<td>0.0095 - 0.0125</td>
</tr>
<tr>
<td>560</td>
<td>630</td>
<td>0.0100 - 0.0135</td>
</tr>
<tr>
<td>630</td>
<td>710</td>
<td>0.0120 - 0.0155</td>
</tr>
<tr>
<td>710</td>
<td>800</td>
<td>0.0135 - 0.0175</td>
</tr>
<tr>
<td>800</td>
<td>900</td>
<td>0.0145 - 0.0195</td>
</tr>
<tr>
<td>900</td>
<td>1000</td>
<td>0.0160 - 0.0215</td>
</tr>
</tbody>
</table>

**Table 1**

Tapered Bore Bearing Drive - Up Specifications (Inches)

**NOTE:**

For bearings with normal clearance, the reduction should be within the lower half of the clearance reduction range for bearings with clearance greater than normal, e.g., C3 (C3 being etched as a suffix to the bearing no.), the clearance reduction should be within the top half of the range. Example: bearing 23152 CCK, 260 mm bore, clearance reduction: 0.0045-0.0055 inches, bearing 23151 CCK/C3, 260 mm bore, clearance reduction: 0.0055-0.0065 inches. Precision type bearings marked with suffix "W4" (calenders, breaker stacks) have the high point of eccentricity marked on the inner race and correspondingly the low points of eccentricity are marked on the roll journals in relation to the roll outside diameter. When mounting the bearings, the high point on inner race and low point on the journal have to be lined up to reduce the overall eccentricity.
### Table "R"

<table>
<thead>
<tr>
<th>BORE DIAMETER d(mm)</th>
<th>Reduction in Radial Internal Clearance Millimeters</th>
<th>TABLE &quot;S&quot; Minimum Permissible Final Clearance in Millimeters after Mounting Bearings with Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVER Incl.</td>
<td>Min. - Max.</td>
<td>Normal</td>
</tr>
<tr>
<td>50</td>
<td>65</td>
<td>0.030 - 0.040</td>
</tr>
<tr>
<td>65</td>
<td>80</td>
<td>0.040 - 0.050</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>0.045 - 0.060</td>
</tr>
<tr>
<td>100</td>
<td>120</td>
<td>0.050 - 0.070</td>
</tr>
<tr>
<td>120</td>
<td>140</td>
<td>0.065 - 0.090</td>
</tr>
<tr>
<td>140</td>
<td>160</td>
<td>0.075 - 0.100</td>
</tr>
<tr>
<td>160</td>
<td>180</td>
<td>0.080 - 0.110</td>
</tr>
<tr>
<td>180</td>
<td>200</td>
<td>0.090 - 0.130</td>
</tr>
<tr>
<td>200</td>
<td>225</td>
<td>0.100 - 0.140</td>
</tr>
<tr>
<td>225</td>
<td>250</td>
<td>0.110 - 0.150</td>
</tr>
<tr>
<td>250</td>
<td>280</td>
<td>0.120 - 0.170</td>
</tr>
<tr>
<td>280</td>
<td>315</td>
<td>0.130 - 0.190</td>
</tr>
<tr>
<td>315</td>
<td>355</td>
<td>0.150 - 0.210</td>
</tr>
<tr>
<td>355</td>
<td>400</td>
<td>0.170 - 0.230</td>
</tr>
<tr>
<td>400</td>
<td>450</td>
<td>0.200 - 0.260</td>
</tr>
<tr>
<td>450</td>
<td>500</td>
<td>0.210 - 0.280</td>
</tr>
<tr>
<td>500</td>
<td>560</td>
<td>0.240 - 0.320</td>
</tr>
<tr>
<td>560</td>
<td>630</td>
<td>0.260 - 0.350</td>
</tr>
<tr>
<td>630</td>
<td>710</td>
<td>0.300 - 0.400</td>
</tr>
<tr>
<td>710</td>
<td>800</td>
<td>0.340 - 0.450</td>
</tr>
<tr>
<td>800</td>
<td>900</td>
<td>0.370 - 0.500</td>
</tr>
<tr>
<td>900</td>
<td>1000</td>
<td>0.410 - 0.550</td>
</tr>
</tbody>
</table>

**Table 2**

**Tapered Bore Bearing Drive - Up Specifications (Millimeters)**

**NOTE:**

For bearings with normal clearance, the reduction should be within the lower half of the clearance reduction range for bearings with clearance greater than normal, e.g., C3 (C3 being etched as a suffix to the bearing no.), the clearance reduction should be within the top half of the range. Example: bearing 23152 CCK, 260 mm bore, clearance reduction: 0.120-0.145 mm; bearing 23152 CCK/C3, 260 mm bore, clearance reduction: 0.145-0.170 mm. Precision type bearings marked with suffix "W4" (calenders, breaker stacks) have the high point of eccentricity marked on the inner race and correspondingly the low points of eccentricity are marked on the roll journals in relation to the roll outside diameter. When mounting the bearings, the high point on inner race and low point on the journal have to be lined up to reduce the overall eccentricity.
CYLINDRICAL BORE BEARING REMOVAL

If the bearing is to be reused after removal, do not apply any removal force through the rolling elements of the bearing.

Cylindrical bearings require the use of a bearing puller in order to remove the bearings. The puller pulls against the bearing ring having an interference fit. For an interference fit on a shaft, the pull must be applied to the inner ring of the bearing. For an interference fit in a bearing housing, the pull must be applied against the outer ring of the bearing. Heating of the bearing or the bearing housing may also be necessary when dismounting the bearing.

TAPERED BORE BEARING REMOVAL

Tapered bore bearings are removed with the use of pressurized oil. The oil is pumped through a hole to a groove in the tapered portion of the shaft under the bearing. Oil is pumped into the groove until its pressure becomes high enough to push the bearing off the taper of the shaft.

Prior to applying the pressure, slacken, but do not remove, the bearing locking ring or locknut.

If the locking ring or locknut is removed before pressure is applied, a danger exists that the bearing can dismount too quickly and fall off the journal. This may cause damage to the bearing and/or the locknut threads and/or the shaft.
Typical grooving and drilling of the shaft to provide this feature is illustrated below.

**NOTE:** Use of grease is not recommended. It hardens and blocks the passages rendering the hydraulic removal feature useless for future applications. However, at times, grease is either the only hydraulic medium available or the only one, which will be effective. Care should be taken to clean the passages in the journal after its use.

Instructions: Remove pipe plug and with lockplate (or locknut) loosened but still in place, attach hydraulic hose and pump. Use SAE #10 to #40 oil; **DO NOT USE GREASE**.
DRYER INSTALLATION

Place gas fired paper dryer with bearings mounted into position on dryer section framing. Ensure that the tending side bearing housing is installed to allow for proper thermal expansion when the dryer is heated. Loosely bolt bearing housings to framing so that dryer can be aligned. Install stainless steel taper pins (not provided by GL&V) after alignment.

ALIGNMENT

Align dryer so that it is level and perpendicular to machine.

Level to ±.005” cross machine
Square to ±.005”.

MISCELLANEOUS HARDWARE TORQUE

Tighten bearing housing mounting bolts to proper torque. See the following table for proper torque of various material bolts. Use these specifications for dryer associated fasteners only.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>20</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>0.3125</td>
<td>18</td>
<td>11</td>
<td>17</td>
<td>25</td>
<td>8</td>
<td>13</td>
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<td>17</td>
</tr>
<tr>
<td>0.375</td>
<td>16</td>
<td>20</td>
<td>31</td>
<td>44</td>
<td>15</td>
<td>23</td>
<td>33</td>
<td>14</td>
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<tr>
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<td>200</td>
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<td>125</td>
<td>322</td>
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<td>117</td>
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<td>8</td>
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<td>644</td>
<td>909</td>
<td>187</td>
<td>483</td>
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<td>175</td>
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<td>636</td>
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<tr>
<td>1.125</td>
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<td>354</td>
<td>794</td>
<td>1288</td>
<td>266</td>
<td>595</td>
<td>966</td>
<td>248</td>
<td>556</td>
<td>901</td>
</tr>
<tr>
<td>1.25</td>
<td>7</td>
<td>500</td>
<td>1120</td>
<td>1817</td>
<td>375</td>
<td>840</td>
<td>1363</td>
<td>350</td>
<td>784</td>
<td>1272</td>
</tr>
<tr>
<td>1.375</td>
<td>6</td>
<td>655</td>
<td>1469</td>
<td>2382</td>
<td>491</td>
<td>1102</td>
<td>1787</td>
<td>459</td>
<td>1028</td>
<td>1668</td>
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<tr>
<td>1.5</td>
<td>6</td>
<td>869</td>
<td>1949</td>
<td>3161</td>
<td>652</td>
<td>1462</td>
<td>2371</td>
<td>609</td>
<td>1365</td>
<td>2213</td>
</tr>
</tbody>
</table>

Note: Lubricated torque values are for SAE 20-SAE 40 oil and can vary greatly depending on the actual lubrication.
DRYER HEAD BOLTS

Never re-torque dryer head bolts. If broken bolts are found, they need to be replaced immediately. Tighten replaced dryer head bolts per the following table:

<table>
<thead>
<tr>
<th>Bolt - diameter (inches)</th>
<th>Recommended Torque (foot-pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>175-225</td>
</tr>
<tr>
<td>7/8</td>
<td>300-350</td>
</tr>
<tr>
<td>1</td>
<td>550-650</td>
</tr>
<tr>
<td>1-1/8</td>
<td>600-700</td>
</tr>
<tr>
<td>1-1/4</td>
<td>700-800</td>
</tr>
</tbody>
</table>

HANDHOLE/MANHOLE COVERS

Handhole/manhole cover bolts should be re-torqued after applying heat to the dryers if the covers have been removed for dryer servicing. Bring the dryers up to operating temperature then remove steam pressure. Torque the handhole/manhole bolts to 200-250 ft-lbs and continue with warm-up procedure.
BEARING LUBRICATION, CIRCULATING OIL SYSTEM
(THE SECTION IS FOR REFERENCE ONLY, THERE IS NO SUPPLIED LUBE SYSTEM WITH THE GAS FIRED PAPER DRYER)

Connect supply and discharge piping as per oil system specifications. Adjust flow meters for proper oil quantity based on the bearing size and steam pressure.

Improper sizing and installation of piping can result in bearing failure, oil leakage, seal failure or additional drive requirements.

BEARING LUBRICATION, GREASE

Grease lubrication is not normally recommended on new dryer installations operating at high temperatures. For this application, Krytox XHT-AC shall be used for the grease.

GUARDING INSTALLATION

Install guarding and warning signs in accordance with OSHA Safety Standards to protect operators and equipment.

WARNING: Failure to comply with OSHA requirements could result in injury to personnel, damage to equipment or fines for non-compliance.
GAS FIRED PAPER DRYER OPERATION

The gas fired paper dryer cylinder supplied is a mild steel cylinder that is designed to be used as an instrument to simulate the drying of paper along a dryer section. The dryer cylinder, or dryer, use the latent heat of the gas flame to dry material that is fed upon the outside surface of the cylinder.

The dimensional information and maximum operating temperature of the paper drying cylinders provided with this equipment is listed in the machine data section of this manual.

Both the front and rear journal of each drying cylinder are drilled and suitably grooved to enable the installation of tapered bore, spherical roller bearings. The journals are also machined to supply and exhaust the gaseous mixture. See the Dryer Assembly drawing for specific dimensional details.

OPERATING SAFETY CONSIDERATIONS

Dryer cylinders are a component of automatic equipment that has various nip points. KEEP ALL BODY PARTS CLEAR OF THE DRYER SECTION UNLESS THE SYSTEM HAS BEEN PROPERLY LOCKED OUT. DO NOT WEAR LOOSE CLOTHING AROUND THE DRYER SECTION.

Dryer cylinders are designed to work at high temperatures. SEVERE BURNS CAN RESULT FROM CONTACT WITH HEATED DRYER CYLINDERS AND NEARBY EQUIPMENT.
Special safety considerations:

1. Dryer cylinders are very hot even several hours after shutdown. Personnel should use caution when operating around the dryer section at all times.
2. Never spray cool or cold water on any hot dryer other than that of the shower.
3. Never run the burner without the water shower being turned on.

**Safety equipment:** Personnel should wear hard hats, safety glasses, and leather gloves when working around the dryer section.
Appendix E: Combustion Controls Manual (Flynn Burner Corporation)
DRUM DRYER
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**SPECIFICATIONS:**

Electrical specifications to conform to USA Standards.
Piping specifications to conform to NFPA 86 Standards.

**GENERAL**

| Type of system: | Drum Heater |

**ELECTRICAL**

| Control system: | Compact-Logix 1769  
A-B PanelView +700 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power:</td>
<td>230V/3PH/60HZ</td>
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<tr>
<td>Control Voltage:</td>
<td>120/1/60</td>
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</table>

**MECHANICAL**

<table>
<thead>
<tr>
<th>Type of burner:</th>
<th>Flynn Series HC-511, 108” FS #026104</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of ribbon:</td>
<td>3 Slot Ribbon</td>
</tr>
<tr>
<td>Burner Max Output Capacity:</td>
<td>15,000 BTU per inch – 1,500,000 BTU total</td>
</tr>
<tr>
<td>Burner deckels:</td>
<td>NONE</td>
</tr>
<tr>
<td>Type of ignition:</td>
<td>Electrode Rod</td>
</tr>
<tr>
<td>Type of sensing:</td>
<td>Sensing Rod</td>
</tr>
<tr>
<td>Combustion air blower size:</td>
<td>DR757</td>
</tr>
<tr>
<td>Exhaust fan size:</td>
<td>NA</td>
</tr>
<tr>
<td>Inlet gas pressure:</td>
<td>1 PSIG MAX</td>
</tr>
<tr>
<td>Compressed air pressure:</td>
<td>80 – 100 PSI</td>
</tr>
</tbody>
</table>
FLYNN BURNER CUSTOMER DRAWING LIST:

LINE AND WIRING 08-3433-00-05 (sheets 1 - 6)

MAIN PANEL ASSEMBLY 08-3433-06

MAIN PANEL ASSEMBLY 08-3433-10

2 BURNER PRETREATER
AIR/GAS PIPING 08-3433-13

HC511-108” FS (3) SLOT
MULTIPLE BOTTOM CENTER INLETS 08-3433-18
I. PRODUCT INSTALLATION

OVERVIEW:
Verify that all components supplied by Flynn Burner and by Customer are available at the installation site. Utility drops and the physical installation of the combustion system components are the responsibility of the customer and should be ready for proper installation and start-up.

The utilities include the following:
1. Gas supply line of the proper size, flow and pressure.

*If the gas supply also supplies other equipment in the plant, it must be sized and run in such a way as to not cause pressure fluctuations to the Flynn combustion system as the other equipment is cycled on and off.

2. Electrical supply of proper voltage and amperage.
   See Line drawing #08-3433-02

5. Exhaust ducting
All Plumbing connections should be made according to local plumbing codes and consist of the following:

   Plumbing the natural gas supply to the piping cabinet.
   Plumbing the air / gas mixture line from the piping cabinet to the burner.
   Plumbing of loose items which include;
       Flexible metal hoses for burner feed.

All electrical connections should be made according to local electrical codes and consist of the following:

   Main three phase power feed to the electrical enclosure located at the piping cabinet.
   Power and control signals between the operator console and piping cabinet enclosure.
   Power and control signals to the exhaust fan and exhaust flow switch.
   PLC communication to existing control system.

The customer is responsible for the installation of the exhaust system.
Exhaust ducting will be required to the exhaust fan, and from the exhaust fan to the roof.
GAS SUPPLY
At a minimum the natural gas supply to the system must be the same pipe size as the main ball valve. If long pipe runs or multiple fittings are needed, then the appropriate pipe diameters should be used in order to allow proper gas supply.

The gas requirements are as follows:

Pressure: 2-7 PSIG
Max volume: 1000 Natural Gas

The pressure entering the system must never exceed seven (7) PSI. If the gas supply is greater than 7 PSI, a pressure reducing regulator must be installed in the gas line before the unit. This regulator, if not supplied with the unit, must be sized properly for the gas consumption of the system.

MIXTURE PIPING
The piping cabinet should be located as close to the burner as reasonably possible. The maximum piping length including fittings should not exceed 50 feet.

Flexible hoses are supplied for the mixture connections to the burner.

ELECTRICAL SYSTEM CONNECTIONS
The main power connections will consist of three phase voltage according to local codes. See Line Diagram drawing #08-3433-02.

The line diagram drawing 08-3433-02 will show all the necessary field connections that must be made for proper system operation.

Special care must be taken when making wire runs in conduit. All low voltage signal wiring must be made with shielded cable in conduit separate from AC voltage wiring to insure that electrical noise is not transmitted into electronic components. Customer interlocks and go signals should be tied into the web handling equipment in such a way that the burner will be shut down in case of a controlled stop, emergency stop, or web break.

The customer should not make any interlock connections not included on the system drawings as this may interfere with the logical functioning of the system.
SYSTEM COMPONENT OVERVIEW

A combustion system typical Flynn F3000 Surface Treating System consists of the burner, air/gas mixing station and control cabinet/HMI-operator interface.

BURNER

The burner consists of the HC-511 - 108” FS triple slot burner and dual ignition transformer.

EXHAUST

The customer supplied & installed butterfly will not be a perfect seal, to insure that there is always a minimum exhaust flow. The dampers) should be adjusted so that there is the maximum exhaust flow without causing turbulence in the flame.

BURNER HC-511-108” FS TRIPLE SLOT

The burner is a cast iron (3) slot. The ribbon is a 3 slot construction rated at 15,000 BTU’s per inch max.

PIPING AND MAIN ELECTRICAL CABINET ASSEMBLY

The piping frame and Main Electrical cabinet are mated together in one unit. The piping frame houses the air/gas piping assembly, consisting of all the motorized valves, solenoids, blocking gas valves, air – gas mixer, zero regulator and other necessary components needed for proper and safe control of the gas flame. The control cabinet mounted to the piping cabinet contains all of the controls, relays, and other various components necessary to logically operate the system.

See Piping drawing #2009-1324-02
BALL VALVE

The main shut off ball valve is placed at the inlet gas connection of the unit. Its sole purpose is to shut the gas supply off to the system during shut down or maintenance.

See Piping drawing #2009-1324-02
   Item #1 1 ¼" ball valve (Flynn part #177646)
MAIN GAS SHUT OFF VALVES

These Dungs valves work in conjunction with each other to automatically shut off the gas supply to the system. One of the “blocking valves” has a pressure gauge to give a visual indication of inlet gas pressure. These valves will shut if the high gas, combustion, or exhaust flow switches are open, and will close automatically under the same conditions.

See Piping drawing #08-3433-13
   Item #2 Flynn part number 405247

BURNER GAS SOLENOIDS

The burner gas solenoids are used to turn the gas flow to the burner on and off. This will occur automatically with cut in speed, or manually with the burner on/off switch.

See Piping drawing #2009-1324-02
   Item #24 Flynn part #404626

ZERO GAS REGULATOR

The zero gas regulator is used in conjunction with the venturi in the air – gas mixer to proportionally supply fuel on demand. As the line changes speeds, the air motorized valve will automatically adjust the air entering the air inlet of the mixer. As the air enters the mixer, a suction is created which draws the fuel from the fuel line. The proper amount of fuel is drawn as a result of the zero gas regulator. The zero gas regulator must never be adjusted in the field.

See Piping drawing #08-3433-13
   Item #3 – Flynn part 160190

AIR – GAS MIXER

The air – gas mixer is a venturi style. The air is used to draw the gas from the gas line. The mixer and it’s orifice are sized to deliver the required BTU output for a given application. If more BTU’s are required, the jet size within the mixer can be increased to allow the BTU increase.

NOTE:
Please consult the factory prior to making changes to the mixing equipment.
Phone: 1-914-636-1320

See Piping drawing #08-3433-13
   Item #8 – Air/Gas mixer 1616 (Flynn part 095000)

COMBUSTION AIR BLOWER

The combustion air blower provides the primary air to mix with the gas for combustion at the burner. It is sized for the specific application, i.e. the burner type and the flame space length.

See Piping drawing #2009-1324-02
   Item #5 Combustion air blower (Flynn part # 404270)
RELIEF VALVE
The relief valve is used to bleed off excess air to insure that the combustion air blower doesn’t overheat. This is especially important when the systems are equipped with an air solenoid shut off valve in the combustion air line. They are usually set so that at high fire, only a small amount of air is being relieved.

See Piping drawing #08-3433-13
  Item #10 Air pressure relief valve. (Flynn part #160034)
  Item #11 Air pressure relief muffler. (Flynn part #127550)

COMBUSTION AIR FILTER
The combustion air filter is used to filter the air going into the combustion air blower. It is very important to keep this filter clean and in place. If the filter becomes clogged the system will not operate properly, and if it is removed and not replaced, dirt and debris will get sucked into the mixing system clogging the burner.

See Piping drawing #08-3433-13
  Item #12 Combustion filter. (Flynn part #116893)

BURNER AIR CONTROL VALVE AND ACTUATOR
The air valve is used to control the firing rate (Btu’s per hour) of the burner. As line speed changes occur, the control computer will automatically adjust the firing rate based on feedback from a speed sensor.

See Piping drawing #08-3433-13
  Item #17 Air butterfly valve assembly. (Flynn part #1777792)

PRESSURE SWITCHES
The system utilizes several pressure switches for the purpose of safety shutdown. These include high and low gas pressure, combustion air, and exhaust. The gas pressure switches are used to insure that proper and safe levels of gas pressure are present in the system. The combustion air pressure switch is used to insure that the combustion air blower is operating properly. The exhaust pressure switch (vacuum), which is mounted external to the system, insures that there is exhaust suction. If any of these switches fail, the system will not start, or will be shut down.

See Piping drawing #08-3433-13
  Item Exhaust pressure switch. (Flynn part #171000)
  Item Combustion air pressure switch. (Flynn part #402638)
  Item Main gas valve with High and Low gas pressure switches. (Flynn part #405247)
The control cabinet contains all the system control components, responsible for the logical and safe running of the system.
**Power Disconnect:** Used to turn the main power off to the system.

**Motor Starters:** Used to control the starting and stopping of the exhaust, and combustion air blowers.

**Control Relays:** Used to control various functions related to the logical operation of the system. One example would be the safety interlock relay, which is used to tie the safety signal into the control computer.

**Honeywell RM7890A1015/B Flame Control w/ Q7800A1005 Sub Base:** This control is used to initiate the ignition cycle, open the gas and air solenoids, monitor the flame signal if present, and shut the gas and air valves if the flame does not ignite or fails after ignition.

**Solid State Relays:** Used to control the logical operation of the system.

**Control Transformer:** Used to supply the 120 VAC necessary for the operation of the control elements in the control cabinet.

**PLC A-B Compact Logix 1769-L23E**

The Allen Bradley SLC is used to control the entire system operation through digital, analog, and serial communications inputs and outputs.

**CONTROL CONSOLE**

The control console, or operator console, is the enclosure which contains the interface necessary to run the system. It consists of an Allen Bradley PanelView Plus 700, and an E-Stop push button. The alarm horn is also mounted on the side of the console, with an adjustment screw for noise level.
EXTERNAL SYSTEM COMPONENTS

Exhaust Fan: The exhaust fan is used to exhaust the products of combustion. The fan is monitored with a pressure switch, as stated above, and will run off of the main supply three phase power.
SYSTEM OPERATION

Boot Screen

Display

The header is the main navigation bar and shown on every page with the exception of the “clean screen” page.

To navigate to a new page simply touch the “tab” corresponding to the desired area of control. When navigation is complete and we are actually on that page, the associated tab will become a darker blue. As shown in the example above, we are now on the burner page. The padlock on the engineering tab means it is password protected and the user must enter the correct username and password to gain access. Once the correct username and password has been entered and accepted, the padlock will shown in the open position (shown above)

General

Numeric displays shown in yellow allow user input (read/write) numeric displays in green are read only.

Touching each tab will direct the user to that particular area of control, which are as follows;

Overview- controls the primary functions like starting and stopping the main drive along with the major set points

Burner – shows the ignition and burner control indicators

Trends – shows the RTD temperature trends

Engineer [password protected] – Contains the main set up variables.

Alarms – shows all active and past alarms. The text will flash red if there are any alarms present. If no alarms are present, the text remains black.

Emergency stop reset

Also shown on the overview screen is the emergency stop reset button.

After the toaster has been powered down or an Emergency Stop has been pressed, the machine is deactivated by means of a safety relay which disconnects all power. Upon resetting the Emergency Stop or applying power for the first time, this relay must be reset. This is done by pressing the button shown after first resetting the main panel.
Main Overview

Display

The overview screen is displayed when the toaster is first powered on.

Here we have control of the local/remote setpoints control and the starting and stopping of the drum.

Buttons

Clean Screen – This starts the clean screen routine which blanks all control so the user can safely wipe the screen of any dust. After 10 seconds it will return to the main overview page.

Local/Remote Setpoints – Control of the temperature and drum speed can be controlled either locally or remotely.

a) Local setpoints. When in local the drum speed and temperature will be shown in yellow indicating that they can be changed on the screen between selected limits.

b) Remote setpoints. In remote setpoints mode, control of the toasting parameters are from the main panel. All setpoint on the screen will become green (read-only)

Start Drum – Starts the drum rotation at the speed selected either locally or remotely. Pressing the start button will start a 5 second, start warning alarm indicating that the drum is about to start. Releasing this button prior to 5 seconds will result in the drum not starting.

Stop Drum – Stops the drum immediately
**Status**

Production Ready Indicator – Indicates that the drum is;

a) Rotating  
b) The doctor blades are in place  
c) The temperature has reached operating setpoint

Drum Pressure – (Future control)

RTD 1~5 – Shows the actual temperature of each RTD probe. If an RTD is not selected, it will not be shown here.

Doctor Blade Indicators – Shown green when proximity switch is detecting the doctor blade in place, gray when the doctor blade is removed

Drive Motor – Shown;  
Gray = Off or not running  
Green = On and drive running  
Red Flashing = drive fault exists

**Sub Displays**

**Clean Screen**

![Clean Screen Now](image)
Burner Display

Main Burner display and control screen. This allows full control of the burner and drum heating.

Buttons

Choose Sensor or Igniter – Allows the selection of either the primary or secondary igniter or sensor

Local/Remote Setpoints – Control of the temperature and drum speed can be controlled either locally or remotely.

  a) Local setpoints. When in local the drum speed and temperature will be shown in yellow indicating that they can be changed on the screen between selected limits.
  b) Remote setpoints. In remote setpoints mode, control of the toasting parameters are from the main panel. All setpoint on the screen will become green (read-only)

Relight – Relights the burner in the event of flame failure (only visible after primary ignition)

Light Burner – Starts the purge and ignition sequence

Shutdown – Starts the automatic shutdown sequence. Cuts of the burner and starts a 6 hour cool down period.

Purge Info – Displays the ignition diagnostic page
Status

Production Ready Indicator – Indicates that the drum is:
   a) Rotating
   b) The doctor blades are in place
   c) The temperature has reached operating setpoint

Numeric Indicators –
   a) Temperature, either local or remote setpoint (see Local/Remote Setpoints)
   b) Actual, actual average temperature of RTD’s that are enabled
   c) Pressure, combustion air pressure
   d) Mod Motor, percentage open command to combustion air modulating valve
   e) Exhaust, speed command for exhaust blower
   f) BTU, Actual BTU output of the burner

Graphic Indicators – This depicts the current status of the burner, the following states exist
   a) Burner Off, burner has not been started
   b) Purging, the purge sequence has been correctly initiated and is timing out
   c) Lighting, the controller is currently trying to establish a flame
   d) Flame Established, a flame is correctly sensed and running under normal control
   e) Flame Failed, burner has failed and a relight is necessary
   f) Closing to Low Fire, after a purge, the burner must close down to light at a lower pressure prior to ignition
   g) Low Fire Hold, the burner is being held in low fire position. This is normally caused by either one or more of the doctor blade proximities has failed or not detected the doctor blade in position or the main drive rotation has not been sensed
   h) Shutdown, the burner shutdown process has been initiated
   i) Burner Cut Off, the toaster is under normal control but has automatically shut off the burner. This will automatically relight once the temperature begins to fall again.
Sub Displays

Igniter Select

Burner Diagnostics

Diagnostics. This is a flowchart corresponding to the safety circuit. Each indicator shows either gray, yellow, green or red flashing. Generically, gray is off, yellow is waiting or checking, green is OK and red is fail.
The indicators are as follows

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Indicator Green</th>
<th>Indicator Yellow</th>
<th>Indicator Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burner off</td>
<td>Burner started</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi Temperature Safety</td>
<td>Hi Temp Safety OK</td>
<td></td>
<td>Hi Temp safety has tripped, reset in panel</td>
</tr>
<tr>
<td>Exhaust Fan</td>
<td>Exhaust fan running</td>
<td>Exhaust fan starting</td>
<td>Exhaust running signal not detected from MCC panel</td>
</tr>
<tr>
<td>Exhaust Air Flo</td>
<td>Exhaust air flow OK</td>
<td>Exhaust fan starting up</td>
<td>No exhaust air flow detected, reset on alarm page</td>
</tr>
<tr>
<td>Valve Closed</td>
<td>Valve proven closed</td>
<td></td>
<td>Valve closed signal not present, not checked after purge</td>
</tr>
<tr>
<td>Hi Fire Position</td>
<td>Valve at hi fire position</td>
<td>Valve is opening up</td>
<td>Valve should have opened up, not checked after purge</td>
</tr>
<tr>
<td>Exhaust Speed</td>
<td>Exhaust fan at 60Hz</td>
<td>Exhaust is starting up</td>
<td>Valve is not at 60Hz during purge, not checked after purge</td>
</tr>
<tr>
<td>Combustion Blower</td>
<td>Blower running</td>
<td></td>
<td>Blower running signal not detected</td>
</tr>
<tr>
<td>Combustion Air Flow</td>
<td>Blower air flow OK</td>
<td>Blower starting up</td>
<td>Blower air pressure switch not detected</td>
</tr>
<tr>
<td>Hi Gas Pressure</td>
<td>Gas pressure OK</td>
<td></td>
<td>Hi gas pressure tripped, reset on alarm page</td>
</tr>
<tr>
<td>Lo Gas Pressure</td>
<td>Gas pressure OK</td>
<td></td>
<td>Lo gas pressure tripped, reset on alarm page</td>
</tr>
<tr>
<td>Purge Time</td>
<td>Purge time complete</td>
<td>Purging, shows time left</td>
<td></td>
</tr>
<tr>
<td>Light Burner</td>
<td>Ignition complete</td>
<td></td>
<td>Flame failed</td>
</tr>
</tbody>
</table>
Trends

Display

This is the main trending page for temperatures. The 6 pens indicate RTD’s 1 through 5 and the setpoin.

Set Minimum/Maximum

Numeric entry scales the trend between these two values and can be used for better resolution. Note, the time span cannot be changed and pens cannot be dynamically disabled.

VCR Buttons

Can be used to scroll backwards and forwards as well as pause the display
Engineer

Display

Here the main engineering settings are accessible under password protection.

Buttons

Configure Panelview – Allows access to the internal panelview configuration settings. See Panelview Plus user manual for more information

Burner Auto/Manual – Sets the operation of the burner. Automatic uses the PID settings to regulate the temperature according to the setpoint. Manual fixes the burner output power

Exhaust Auto/Manual – Allows the exhaust control and speed to be set by the program or by the user

Exhaust On/Off – [manual mode only] Allows the starting and stopping of the exhaust fan.

Configure Burner – Allows further settings of the burner (authorized personnel only)
**Numeric Inputs**

Local Burner Setpoint – Local setpoint only

Actual Temperature – Average RTD temperature display

Manual Setpoint – Manual setpoint for burner when manual control selected

  - Entered in inches water column if cascade selected
  - Entered in percent if cascade control not selected

Actual Pressure – Combustion air pressure

Mod Motor Command – Modulating motor analog command (cascade control only)

CV Out – Result of primary PID (cascade control only)

Exhaust Fan Manual Speed – Speed command for exhaust fan when operating in manual

Exhaust Fan Actual Speed – Current speed of exhaust fan

Firing Rate – Output power of burner in BTU’s

**Sub Displays**

**Configure Burner (authorized personnel only)**

Used for advance settings of the burner control. Changing settings here could adversely affect production.

![Configure Burner](image)

**Buttons**

RTD 1~5 Enable/Disable – Allows the operation of the individual RTD’s. Only the RTD’s that are enabled are averaged into the control algorithm.

Cascade On/Off – Sets the method of control for the burner. Cascade on will drive the firing rate valve (modulating motor) to a desired pressure to achieve the firing rate required. Cascade off will drive the valve to a certain position (0-100% = full closed to full open) regardless of the input pressure
**Numeric Inputs**

Low fire setpoint – Adjusts the minimum pressure the burner will achieve under normal cascade control.

High fire setpoint – Adjusts the maximum pressure the burner will achieve under normal cascade control.

Ignition setpoint – Adjusts the ignition pressure the burner will drive to before ignition is attempted.

Burner Cutback – Adjusts the degree adder the burner will add to the setpoint before cutting the burner off.

Hi Temperature Limit – Maximum temperature allowable before burner cuts off.

Burner Orifice Size – Adjusts the orifice size in the BTU calculation.
Alarms

Display

Default alarm page

Buttons

EStop Reset – After the toaster has been powered down or an Emergency Stop has been pressed, the machine is deactivated by means of a safety relay which disconnects all power. Upon resetting the Emergency Stop or applying power for the first time, this relay must be reset. This is done by pressing the button shown after first resetting the main panel.

Silence Alarm – Mutes the audible alarm horn
Alarm Reset – Resets an alarm if required
Alarm Reset – Resets an alarm if required
Alarm History – Shows the alarm history page
Alarm Statistics – Shows the alarm statistics page
## Alarm Messages

<table>
<thead>
<tr>
<th>TAG</th>
<th>ALARM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM.WORD[0].0</td>
<td>#1 - LOW BATTERY ALARM</td>
<td>LOW BATTERY IN PLC</td>
</tr>
<tr>
<td>ALARM.WORD[0].1</td>
<td>#2 - LOCAL ENBT COMMUNICATION FAULT</td>
<td>LOCAL ETHERNET CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[0].2</td>
<td>#3 – LOCAL EMBEDDED INPUT CARD FAULT</td>
<td>LOCAL INPUT CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[0].3</td>
<td>#4 - LOCAL EMBEDDED OUTPUT CARD FAULT</td>
<td>LOCAL OUTPUT CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[0].4</td>
<td>#5 - LOCAL EMBEDDED ANALOG CARD FAULT</td>
<td>LOCAL ANALOG CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[0].5</td>
<td>#6 - LOCAL EMBEDDED COUNTER CARD FAULT</td>
<td>LOCAL COUNTER CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[0].6</td>
<td>#7 - LOCAL EXPANSION RTD CARD FAULT</td>
<td>EXPANSION RTD CARD HAS FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[1].0</td>
<td>#33 - IO CARD 01 CHANNEL FAULT</td>
<td>CHANNEL FAULTED ON LOCAL CARD</td>
</tr>
<tr>
<td>ALARM.WORD[1].1</td>
<td>#34 - IO CARD 02 CHANNEL FAULT</td>
<td>CHANNEL FAULTED ON LOCAL CARD</td>
</tr>
<tr>
<td>ALARM.WORD[1].2</td>
<td>#35 - IO CARD 03 CHANNEL FAULT</td>
<td>CHANNEL FAULTED ON LOCAL CARD</td>
</tr>
<tr>
<td>ALARM.WORD[1].3</td>
<td>#36 - IO CARD 04 CHANNEL FAULT</td>
<td>CHANNEL FAULTED ON LOCAL CARD</td>
</tr>
<tr>
<td>ALARM.WORD[1].4</td>
<td>#37 - IO CARD 05 CHANNEL FAULT</td>
<td>CHANNEL FAULTED ON LOCAL CARD</td>
</tr>
<tr>
<td>ALARM.WORD[1].5</td>
<td>#38 - IO CARD 05 CHANNEL 0 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[1].6</td>
<td>#39 - IO CARD 05 CHANNEL 1 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[1].7</td>
<td>#40 - IO CARD 05 CHANNEL 2 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[1].8</td>
<td>#41 - IO CARD 05 CHANNEL 3 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[1].9</td>
<td>#42 - IO CARD 05 CHANNEL 4 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[1].10</td>
<td>#43 - IO CARD 05 CHANNEL 5 OPEN WIRE FAULT</td>
<td>OPEN WIRE ON RTD PROBE</td>
</tr>
<tr>
<td>ALARM.WORD[3].0</td>
<td>#97 - PANEL EMERGENCY STOP PRESSED</td>
<td>EMERGENCY STOP PRESSED ON PANEL DOOR</td>
</tr>
<tr>
<td>ALARM.WORD[3].1</td>
<td>#98 - EMERGENCY STOP RELAY FAILED TO RESET</td>
<td>EMERGENCY STOP RELAY DID NOT RESET, CHECK CIRCUIT</td>
</tr>
<tr>
<td>ALARM.WORD[3].2</td>
<td>#99 - MAIN DRIVE CIRCUIT BREAKER TRIPPED</td>
<td>MCB SUPPLYING SEW MOVIMOT HAS TRIPPED</td>
</tr>
<tr>
<td>ALARM.WORD[3].3</td>
<td>#100 - BLOWER MAIN CIRCUIT BREAKER TRIPPED</td>
<td>MCB SUPPLYING COMBUSTION BLOWER HAS TRIPPED</td>
</tr>
<tr>
<td>ALARM.WORD[3].4</td>
<td>#101 - MAIN DRIVE NOT RUNNING</td>
<td>MAIN DRIVE NOT RUNNING, CHECK CHAIN PROXIMITY SWITCH</td>
</tr>
<tr>
<td>ALARM.WORD[3].5</td>
<td>#102 - MAIN DRIVE STOPPED OR FAULTED, BURNER DISABLED</td>
<td>DRIVE STOPPED (SEE ABOVE) SO BURNERS DISABLED</td>
</tr>
<tr>
<td>TAG</td>
<td>ALARM</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>ALARM.WORD[3].6</td>
<td>#103 - EMERGENCY STOP RESET REQUIRED</td>
<td>EMERGENCY STOP HAS NOT BEEN RESET</td>
</tr>
<tr>
<td>ALARM.WORD[4].0</td>
<td>#129 - EXHAUST FAILED TO RUN</td>
<td>EXHAUST DRIVE IN MCC IS NOT RUNNING OR FAULTED</td>
</tr>
<tr>
<td>ALARM.WORD[4].1</td>
<td>#130 - BLOWER FAILED TO RUN</td>
<td>BLOWER STARTER DID NOT PULL IN</td>
</tr>
<tr>
<td>ALARM.WORD[4].2</td>
<td>#131 - NO EXHAUST AIR FLOW DETECTED</td>
<td>EXHAUST PRESSURE SWITCH HAS OPENED, CHECK FOR VIBRATION OR NO AIR</td>
</tr>
<tr>
<td>ALARM.WORD[4].3</td>
<td>#132 - NO COMBUSTION BLOWER AIR FLOW DETECTED</td>
<td>BLOWER PRESSURE SWITCH HAS OPENED, CHECK FOR VIBRATION OR NO AIR</td>
</tr>
<tr>
<td>ALARM.WORD[4].4</td>
<td>#133 - EXHAUST PRESSURE SWITCH FAILED OR JUMPERED OUT</td>
<td>#133 - EXHAUST PRESSURE SWITCH FAILED OR JUMPERED OUT</td>
</tr>
<tr>
<td>ALARM.WORD[4].5</td>
<td>#134 - COMBUSTION BLOWER PRESSURE SWITCH FAILED OR JUMPERED OUT</td>
<td>BLOWER PRESSURE SWITCH IS MADE AND BLOWER NOT RUNNING</td>
</tr>
<tr>
<td>ALARM.WORD[4].6</td>
<td>#135 - VALVE NOT IN CLOSED POSITION</td>
<td>MAIN GAS VALVE NOT CLOSED</td>
</tr>
<tr>
<td>ALARM.WORD[4].7</td>
<td>#136 - HI GAS PRESSURE DETECTED</td>
<td>HIGH GAS PRESSURE SEEN IN GAS LINE</td>
</tr>
<tr>
<td>ALARM.WORD[4].8</td>
<td>#137 - HI TEMPERATURE ALARM</td>
<td>HI TEMPERATURE DETECTED IN EXHAUST STACK</td>
</tr>
<tr>
<td>ALARM.WORD[4].9</td>
<td>#138 - PURGE TIMER SET TOO SHORT</td>
<td>(INDICATOR ONLY) PURGE TIMER IS NOT LONG ENOUGH</td>
</tr>
<tr>
<td>ALARM.WORD[4].10</td>
<td>#139 - FLAME FAILED, BURNER LOCKOUT</td>
<td>FLAME FAILED FROM HONEYWELL CONTROLLER</td>
</tr>
<tr>
<td>ALARM.WORD[4].11</td>
<td>#140 - AT LEAST ONE RTD MUST BE SELECTED</td>
<td>ALL RTD’S HAVE BEEN MANUALLY DE-SELECTED</td>
</tr>
<tr>
<td>ALARM.WORD[4].12</td>
<td>#141 - LOW GAS PRESSURE DETECTED</td>
<td>LOW GAS PRESSURE OR MANUALLY SHUT GAS VALVE</td>
</tr>
<tr>
<td>ALARM.WORD[4].13</td>
<td>#142 - PRESSURE SENSOR SIGNAL LOST</td>
<td>ANALOG PRESSURE SENSOR READING ZERO THOUGH PRESSURE SWITCH IS MADE</td>
</tr>
<tr>
<td>ALARM.WORD[4].14</td>
<td>#143 - BURNER NOT AT HI FIRE POSITION TO PURGE</td>
<td>BURNER HAS NOT OPENED TO HI FIRE POSITION (HONEYWELL INTERNAL CAM)</td>
</tr>
<tr>
<td>ALARM.WORD[4].15</td>
<td>#144 - EXHAUST NOT RUNNING AT FULL SPEED</td>
<td>EXHAUST NOT RUNNING AT SPEED (TAKEN FROM MCC)</td>
</tr>
<tr>
<td>ALARM.WORD[4].16</td>
<td>#145 - OVER TEMPERATURE LOCKOUT</td>
<td>SOFTWARE OVER-TEMPERATURE LOCKOUT TRIPPED, RESET ALARM TO CONTINUE</td>
</tr>
<tr>
<td>ALARM.WORD[4].17</td>
<td>#146 - DOCTOR BLADE PROXIMITY SWITCH FAILED</td>
<td>ONE PROXIMITY IS MADE AND ONE NOT, BOTH SHOULD BE SAME STATE</td>
</tr>
</tbody>
</table>
**Maintenance**

System maintenance is relatively simple. The main parts of the system which should be maintained consist of the burner, exhaust blower, and the combustion air filter.

**BURNER:**
The burner ribbon must be kept clean and free of dirt and debris. It may be cleaned with compressed air blown through the ribbon, or the gentle use of a torch tip cleaner to poke any deposits through the ribbon, where they may be blown out. The ribbon must not be scrubbed, as this may bend the metal ribbon used to form the flame ports. If the burner ribbon becomes very clogged, then it must be removed and returned to the factory for re-ribboning.

The electrodes must also be kept in working order. When they become old and worn, they should be replaced.

The electrode wires should also be checked regularly to insure that they are not cracked, or broken.

**EXHAUST FAN:**
The bearings on the exhaust fan should be greased regularly to insure long life.

**COMBUSTION AIR FILTER:**
This filter should be checked weekly, and the pre-filter blown out to insure system operation. The pre-filter should be changed approximately every 3 weeks or as needed. The filter element should be changed every 6 weeks or as needed.
### RECOMMENDED SPARE PARTS LIST FOR AIR-GAS PIPING ASSEMBLY

<table>
<thead>
<tr>
<th>Part #</th>
<th>Qty</th>
<th>Description</th>
<th>Price / each</th>
</tr>
</thead>
<tbody>
<tr>
<td>407799</td>
<td>1</td>
<td>combustion air blower PFR757</td>
<td>$2200.00</td>
</tr>
<tr>
<td>116893</td>
<td>1</td>
<td>Combustion Air Filter</td>
<td>$585.00</td>
</tr>
<tr>
<td>300417</td>
<td>1</td>
<td>Air Transducer assembly</td>
<td>$690.00</td>
</tr>
<tr>
<td>402638</td>
<td>1</td>
<td>Air pressure switch</td>
<td>$79.00</td>
</tr>
<tr>
<td>119661</td>
<td>1</td>
<td>Vacuum gauge</td>
<td>$70.00</td>
</tr>
<tr>
<td>303105</td>
<td>1</td>
<td>Valve Air Motorized assembly</td>
<td>$1950.00</td>
</tr>
</tbody>
</table>

### RECOMMENDED SPARE PARTS LIST FOR TREATER STATION ASSEMBLY

<table>
<thead>
<tr>
<th>Part #</th>
<th>Qty</th>
<th>Description</th>
<th>Price / each</th>
</tr>
</thead>
<tbody>
<tr>
<td>300489</td>
<td>1</td>
<td>Burner Assembly</td>
<td>$2500.00</td>
</tr>
<tr>
<td>175400</td>
<td>1</td>
<td>Ignition Transformer</td>
<td>$85.00</td>
</tr>
<tr>
<td>089600</td>
<td>4</td>
<td>Ignition Electrode</td>
<td>$47.25</td>
</tr>
</tbody>
</table>

### RECOMMENDED SPARE PARTS LIST FOR MAIN PANEL ASSEMBLY

<table>
<thead>
<tr>
<th>Part #</th>
<th>Qty</th>
<th>Description</th>
<th>Price / each</th>
</tr>
</thead>
<tbody>
<tr>
<td>158608</td>
<td>1</td>
<td>Honeywell Flame Relay</td>
<td>$235.00</td>
</tr>
<tr>
<td>158724</td>
<td>1</td>
<td>Surge Protector</td>
<td>$167.00</td>
</tr>
<tr>
<td>158611</td>
<td>1</td>
<td>Flame Relay Amplifier</td>
<td>$169.00</td>
</tr>
</tbody>
</table>
FLYNN BURNER CUSTOMER DRAWING LIST:

LINE AND WIRING 08-3433-00-05 (sheets 1 - 6)

MAIN PANEL ASSEMBLY 08-3433-06

MAIN PANEL ASSEMBLY 08-3433-10

2 BURNER PRETREATERS 08-3433-13

AIR/GAS PIPING

HC511-108” FS (3) SLOT
MULTIPLE BOTTOM CENTER INLETS 08-3433-18
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HONEYWELL & CONTROL WIRING .......... SHEET 2
PLC IO WIRING ........................ SHEET 3
PLC ANALOG WIRING ................... SHEET 4
THERMOCOUPLE CARD WIRING .......... SHEET 5
PANEL LAYOUT ........................ SHEET 6
RECOMMENDED SPARE PARTS (TBD) ...... SHEET 7

-----

WIRING NOTES

---
1. UNLESS SPECIFIED ALL CONTROL WIRING TO BE THHN
2. UNLESS SPECIFIED ALL VFD WIRING TO BE XHHW2
3. ALL DC WIRING TO HAVE GROUNDED COMMON
4. CONTROL TRANSFORMER TO HAVE GROUNDED COMMON
5. ALL MOTOR LEADS TO BE TERMINATED ON TERMINALS PROVIDED
6. ALL FIELD WIRING TO BE TERMINATED ON TERMINALS PROVIDED
7. ALL CABLE NUMBERS MUST FOLLOW THESE DIAGRAMS
8. ALL CABLES MUST BE NUMBERED ON BOTH ENDS
9. SPARE CONDUCTORS SHOULD BE LABELLED ACCORDINGLY
10. SAFETY DEVICES TO BE INDIVIDUALLY RETURNED TO PANEL
11. ALL MOTOR GROUNDS TO BE LANDED AT TERMINALS PROVIDED
12. ALL MOTORS MUST BE INDIVIDUALLY GROUNDED
13. ALL FIELD Wiring MUST CONFORM TO NFPA & LOCAL CODES

-----

COMMUNICATION INFORMATION

---
PLC NAME ---------------------- TBD
IP ADDRESS --------------------- TBD
SUBNET ------------------------- TBD
GATEWAY ----------------------- TBD

-----

DEPENDENCIES

---
PANELVIEW PLUS 700 T --------- TBD

-----

LEGEND INFORMATION

---

1. UNLESS SPECIFIED ALL CONTROL WIRING TO BE THHN
2. UNLESS SPECIFIED ALL VFD WIRING TO BE XHHW2
3. ALL DC WIRING TO HAVE GROUNDED COMMON
4. CONTROL TRANSFORMER TO HAVE GROUNDED COMMON
5. ALL MOTOR LEADS TO BE TERMINATED ON TERMINALS PROVIDED
6. ALL FIELD WIRING TO BE TERMINATED ON TERMINALS PROVIDED
7. ALL CABLE NUMBERS MUST FOLLOW THESE DIAGRAMS
8. ALL CABLES MUST BE NUMBERED ON BOTH ENDS
9. SPARE CONDUCTORS SHOULD BE LABELLED ACCORDINGLY
10. SAFETY DEVICES TO BE INDIVIDUALLY RETURNED TO PANEL
11. ALL MOTOR GROUNDS TO BE LANDED AT TERMINALS PROVIDED
12. ALL MOTORS MUST BE INDIVIDUALLY GROUNDED
13. ALL FIELD Wiring MUST CONFORM TO NFPA & LOCAL CODES

-----

WIRING NOTES

---
1. UNLESS SPECIFIED ALL CONTROL WIRING TO BE THHN
2. UNLESS SPECIFIED ALL VFD WIRING TO BE XHHW2
3. ALL DC WIRING TO HAVE GROUNDED COMMON
4. CONTROL TRANSFORMER TO HAVE GROUNDED COMMON
5. ALL MOTOR LEADS TO BE TERMINATED ON TERMINALS PROVIDED
6. ALL FIELD WIRING TO BE TERMINATED ON TERMINALS PROVIDED
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8. ALL CABLES MUST BE NUMBERED ON BOTH ENDS
9. SPARE CONDUCTORS SHOULD BE LABELLED ACCORDINGLY
10. SAFETY DEVICES TO BE INDIVIDUALLY RETURNED TO PANEL
11. ALL MOTOR GROUNDS TO BE LANDED AT TERMINALS PROVIDED
12. ALL MOTORS MUST BE INDIVIDUALLY GROUNDED
13. ALL FIELD Wiring MUST CONFORM TO NFPA & LOCAL CODES

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COMMUNICATION INFORMATION

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PLC NAME ---------------------- TBD
IP ADDRESS --------------------- TBD
SUBNET ------------------------- TBD
GATEWAY ----------------------- TBD

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DEPENDENCIES

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PANELVIEW PLUS 700 T --------- TBD

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LEGEND INFORMATION

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1. UNLESS SPECIFIED ALL CONTROL WIRING TO BE THHN
2. UNLESS SPECIFIED ALL VFD WIRING TO BE XHHW2
3. ALL DC WIRING TO HAVE GROUNDED COMMON
4. CONTROL TRANSFORMER TO HAVE GROUNDED COMMON
5. ALL MOTOR LEADS TO BE TERMINATED ON TERMINALS PROVIDED
6. ALL FIELD WIRING TO BE TERMINATED ON TERMINALS PROVIDED
7. ALL CABLE NUMBERS MUST FOLLOW THESE DIAGRAMS
8. ALL CABLES MUST BE NUMBERED ON BOTH ENDS
9. SPARE CONDUCTORS SHOULD BE LABELLED ACCORDINGLY
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WIRING NOTES

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REVISIONS:

DATE: 11-26-08

APPROVED: 25102

DRAWN BY: 25103

FLYNN BURNER CORPORATION
NEW ROCHELLE - NEW YORK

D-SHEET NUMBER - DRAWING NO. 08-3433-04

V/I in 1-

V/I in 0-

I in 1+

V in 3+

V/I in 3-

I in 3+

V/I in 2-

I in 2+

ANLG Com

V out 0+

I out 0+

L:3:O.Ch0Data

L:3:I.Ch1Data

MODUTROL

AIR VALVE

WHT

BLK

42801

42701

SLD

WHT

BLK

42601

42501

L:3:O.Ch1Data

L:3:I.Ch2Data

42101

42201

WHT

BLK

41801

41701

L:3:I.Ch3Data

L:3:I.Ch0Data

AIR PRESSURE

COMBUSTION

WHT

BLK

41501

41401

WHT

BLK

41201

41101

41001

40901

L:3:I.Ch2Data

L:3:I.Ch1Data

LINE #113 TO REF.

LINE #377 FROM REF.

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LINE #113 TO REF.

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REVISIONS:

DATE: 11-26-08

SCALE: 5

APPROVED: 

DRAWN BY: FLYNN BURNER CORPORATION
NEW ROCHELLE - NEW YORK

D-SHEET NUMBER - DRAWING NO.
08-3433-05
Appendix F: System Characterization Procedure
Procedure for system characterization and tune up

1. Start the GFDD system from the control panel (make sure that drum is rotating, purging complete, interlocks enabled, burner ignited and flame proven).

2. Set rotation speed to 2 RPM and setpoint temperature to 250F (make sure that doctor blade is loaded with 15 psi and properly adjusted for uniformity and all 5 RTDs are in service).

3. Record measurements every 10 minutes (RTD readings and corresponding drum surface temperature in close proximity to RTD location by using contact TC).

4. When reaching the steady state operation (at least 1-2 cycles between +1 degree over setpoint and +5 degrees over setpoint) the system is ready for the product application. Keep optical scanner up and running for the product quality measurement.

5. Run the product until product scan numbers are going to be stabilized. If product is lighter than required, stop the product application, slow down the drum to 1 RPM, wait for steady state conditions and repeat the production trial. If product still light DO NOT reduce rotation speed below 1 RPM – increase setpoint temperature to 260F (or 280F, 300F, as needed). Do not exceed 320F as setpoint temperature (over 450F drum temperature). If product is darker than required, stop the product application, accelerate drum rotation to 3 RPM, wait for steady state conditions and repeat the production trial. If product darker again – accelerate drum rotation until getting the required results.

6. Continue data collection every 5-10 minutes during all the runs along with the appropriate product scans. Upon completion of trial run (item 5) operation team is going to have all the curves for qualified characterization of the commercial production process.
1.1.1. DRUM DRYER MARKETING CALLS REPORT

To: Dr. Yaroslav Chudnovsky
Gas Technology Institute
1700 South Mount Prospect Road
Des Plaines, Illinois  60018

From: Tod Bedrosian
Bedrosian & Associates

Bedrosian & Associates contacted hundreds of commercial agricultural products firms throughout the nation in search of firms that might be interested in the new gas-fired drum dryer technology developed by Gas Technology Institute. A separate report and record of all the calls made during the work period in August, 2009 is being sent to Dr. Yaroslav Chudnovsky at GTI.

This report is a synopsis of the companies that responded with sufficient interest that Bedrosian & Associates recommends drum dryer technology information be sent to them.

Bedrosian & Associates is available to assist with any inquiries GTI may have concerning these marketing/research calls.

The information is incomplete in some cases because firms would not give us “confidential” business information, but in all cases we have provided sufficient contact information.
Many of these firms only asked for information and may not be viable leads. But we have made notes about some of the firms that expressed a sincere interest in talking to GTI about gas-fired drum dryers.

1) 6 Cents Diversified Inc. 207-780-1101

Davey Pruzanski info@living nuts.com

746 Post Road Bowdoinham ME 04008-6015

Comments: Very small drying operation without drum dryer, but they are interested in looking at the technology

2) American Spoon Foods Inc. 231-347-9030

P.O. Box 566 Petoskey MI 49770

Send information to Paul Ramey at Pramey@Spoone.net.com

Comments: They send cherries out to be dried and would not release name of drying firm, but will send GTI information to the dryer.

3) Basic American Foods Inc. 925-472-4000

Gary Dunn 208-785-8779

2121 N. California Blvd., Ste. 400 Walnut Creek CA 94596-2066

Comments: Mr. Dunn sounded very interested. Slava has sent him some preliminary information.

4) Campbell’s Soup Co. 1-856-342-4800
1 Campbell Place  Camden  NJ  08103-1701
Mr. Bill Banks  (856) 432-4953  (Associate of Mary Tenant)
Comments: He would like to talk about the technology.

5) Casa de Fruta  408-842-7282
831-637-2781
10021 Pacheco Pass Hwy  Hollister  CA  95023
Send information to Joe Zanger at joe@casadefruta.com
Comments: They don’t have drum dryers, but would like to learn more.

6) Glasgow Spray-Dry Inc.  270-651-2146
1117 Cleveland Ave.  Glasgow  KY  42141
KJwilliams@bluegrassdairy.com  Kerry Williams  270-651-2146
Comments: Unsure if they have drum dryer, but they would like information.

7) Hegin’s Potato Products L.L.C.  570-695-0909
P.O. Box 27  Hegins  PA  17938-0027
Comments: They do have a drum dryers and would like to talk.

8) Rizo-Lopez Foods Inc.
Sam Ram, Plant Manager  sram@rizolopez.com
6625 2nd Street  Riverbank
Comments:
Generally interested.
This company is not currently using drum dryers, but may look at acquiring GFDD in 3-4 years.
9) Simplot Food Group
alan.christie@simplot.com
P.O. Box 9386  
Boise, ID 83707
Comments: Actively interested.
This company uses direct-fire natural gas to dry potato flakes. E-mail info to alan.christie@simplot.com

10) Smeltzer Orchard Co.
info@smeltzerorchards.com
6032 Jofield Rd.  
Frankfort, MA 49635
“Smeltzer does not participate in surveys.” Okay to send info to info@smeltzerorchards.com.

11) Setton’s International Foods
631-543-8090
info@settonfarms.com
85 Austin Blvd.  
Commack  
NY 11725
Generally interested. E-mail info to info@settonfarms.com.

12) Washington Potato Company
509-349-8803
Steve R., Plant Manager  
stever@oregonpotato.com
1900 1st Avenue N.W.  
Warden  
WA 98857
Comments: Generally interested.
This company currently uses steam dryers only and "will be burdened with these for some time."

13) Tree Top Inc. 509-697-7251
Andy Juarez
P.O. Box 248 Selah WA 98942
Comments: Actively interested. This company uses steam fired by natural gas to dry apple slurry. Prefers to receive info via U.S. mail, ATTN: Andy Juarez.

14) World Food Products Inc. 209-531-2330 Marty Van Duyn
marty@worldfoodproducts.com
2208 Pine Street Ceres CA 95307
Comments:
This is a packing company. Send info to marty@worldfoodproducts.com and he will distribute to processors.

15) Idaho Fresh-Pak Inc. 208-754-4686 Scott Pood
P.O. Box 130 Lewisville ID 83431
Comments:
Mr. Scott's # is: 208-754-8156. Yes, send info.
16) Idaho Pacific Corporation
P.O. Box 478
Todd Sutton
208-538-6971
Ririe ID 83443
Yes, send info. Very interested. They have 10 steam drum dryers now that dry potatoes.

17) Jade Food Products Inc.
94-476 Koaki Street
Waipahu HI 96797-2874
808-678-8886
Yes, send info. Use propane.

18) Lance Inc.
Greg Flickinger
8600 South Blvd.
Charlotte NC 28273
800-438-1880
Yes, send info. Starting 2 new plants. Now have direct fire ovens.

19) L’Espirit De Campagne Inc.
P.O. Box 3130
Winchester VA 22604
540-955-1014
Yes, send info.

20) Lester Farms
Stan
530-795-2693
Lester  
4317 Margaret Lane  Winters  CA  95694  
Send info.

21) Maine Wild Blueberry Co. 207-255-8364  
Ken Fullerton  
cfullerton@oxforfrozenfoods.com  
50 Elm Street  Machias  ME  04654  

22) Mariani Packing Company, Inc.  707-452-2853  
Todd Garcia  
500 Crocker Avenue  Vacaville  CA  95688  
Send info.

23) Oregon Potato Co.  541-481-2715  
Barry  
P.O. Box 169  Boardman OR  97818-0169  
Comments: They have steam drum dryers now that dry potatoes. Capacity is 15,000 lbs and hour. They would like information.