FINAL PROJECT – OVERVIEW:

You are tasked with designing the electrical and control systems for an automated, conveyor-driven, transportation system that will be used to transport the raw materials used in a steel recycling plant from the loading area to the electric arc furnace (EAF) and then to the final casting location. Both the primary components (conveyors/motors, sensors types/locations, etc.) and the basic operational characteristics of the system have already been specified; your task will be to integrate the specified components into a working system, such that you provide (by design) all of the other components (transformers, contactors, VFDs, etc.) needed to make the system functional, and to design/program the control system required for complete system operation.

This project will be completed by students working in groups of two. Each group is expected to complete the project as a team and to submit a single formal report that is jointly-written by both group members.

PROJECT EVALUATION:

Although the overall project grades will be assigned to each student individually, 85% of the available points will be awarded equally to all group members based on the group components of the project. The remaining 15% of the available points will be awarded based on the results of a final project meeting that each student must attend individually.

The primary group and individual grading components are as follows:

Primary Group Grading Components

- Timely completion and accuracy of the required project components,
- Quality of formal report that documents all aspects of the system's design/operation, and
- Demonstration/verification of proper system operation (simulated in the laboratory)

Individual Grading Component

- Individual knowledge of the overall design and operation of the system including (but not limited to) the theoretical concepts applied when designing the system and the function/operation of the individual system components. This includes both the physical components (VFDs, overload relays, contactors, etc.) used as part of the actual system and the logical components (XICs, timers, OTEs, etc.) used within the PLCs ladder-logic program.

FINAL PROJECT – GRADE BREAKDOWN:

Electrical System Design / Documentation ———— **20%**
(Included as part of "Formal Report")
Overall Formal Report ———— **30%**
(Requirements presented at end of this document)
System Operation / PLC Program ———— **35%**
(Points deducted for improperly operating system)
Individual Knowledge (from Project Meeting) ———— **15%**

General Description of System and Primary Components:

Introduction:

The steel recycling center has an area where the raw materials utilized for the steel-making process are stored. A crane-operator loads the scrap/recycled steel into a large crucible, after which a conveyor system transports it to an electric arc-furnace (EAF) for melting. Once the melting process is complete, the conveyors transport the molten steel from the EAF to a casting location where the molten steel can be poured from the crucible into molds to form steel billets. When the casting is complete, the empty crucible is then returned to the loading area where is it once again filled with scrap/recycled steel.

Note that, due to both equipment limitations in the Electric Machines Lab and the amount of time until the end of the semester, parts of this process have been simplified or omitted in order to:

- allow for the implementation of a scale-model system in the lab that can be used to verify the operational logic of the ladder-logic program that is required for the programming portion of this project, and to
- limit the scope of the project such that it can feasibly be completed by the project deadline.

Primary System Components:

The proposed system primarily consists of three overhead, conveyor units that are used to transport the plant's two crucibles between their loading, melting and pouring locations. A variety of sensors are placed through-out the system, each performing a specific function with respect to the overall operation of the system.

Figure #1 shows the overall layout of the lab-bench "model" for the proposed system including the relative locations of the optical detectors. The key positions for the crucibles, as defined in the following sections, are also shown in the figure.

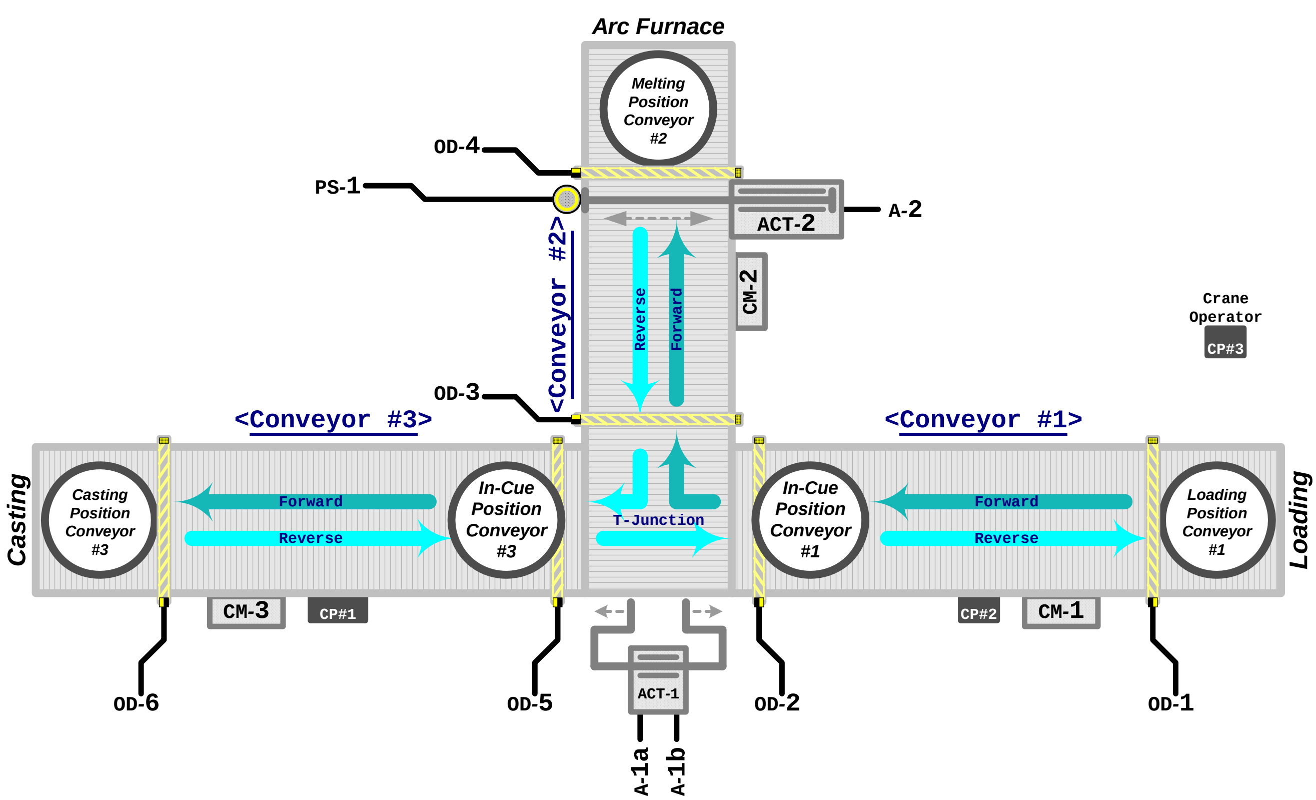


Figure #1 – Overall System Layout with Key Positions Shown (Top View)

Control Panels (Pushbuttons / Indicators):

	Pushbuttons	Indicators
CP#1 (Main Panel):	Start Stop E-Stop	System Operational Emergency Stop Arc Furnace Active Pouring in Progress
CP#2 (Sub-Panel):	E-Stop	System Operational Emergency Stop Arc Furnace Active Pouring in Progress
CP#3 (Crane Op):	E-Stop Fill Complete Return Empty	System Operational Emergency Stop

PLC – Input & Output Schedule:

PLC – Input & Output Schedule			
Input	Description	Output	Description
0	EAF Door Sensor DS-1	0	Actuator #1a (2→1)
1	Optical Detector OD-1	1	Actuator #1b (2→3)
2	Optical Detector OD-2	2	Conveyor #2 Motor
3	Optical Detector OD-3	3	Conveyor #3 Motor
4	Optical Detector OD-4	4	Conveyor #2 Reverse
5	Optical Detector OD-5	5	Conveyor #3 Reverse
6	Optical Detector OD-6	6	Actuator #2 (Door Close)
7	"Melting Complete" Signal	7	
8	"Pour Complete" Signal	8	System Operational Indicator
9	Motor#2 Overload	9	Emergency Stop Indicator
10	Motor#3 Overload	10	Arc Furnace Indicator
11	"Start" Pushbutton	11	Pouring Indicator
12	"Fill Complete" Pushbutton	12	"Ready to Melt" Signal
13	"Return Empty" Pushbutton	13	"Ready to Pour" Signal
14	"Shutdown" Pushbutton	14	Safety Lights
15	"Emergency Stop" Pushbutton	15	Safety Horn

SYSTEM NETWORK CONFIGURATION:

System Network Configuration		
Device	Description	IP Address
PC	Desktop Computer w/ RSLogix 5000 Software	192.169.4.1
PLC	Compact Logic – Programmable Logic Controller	192.169.4.32
VFD	PowerFlex40 – Variable Frequency Drive	192.169.4.40

System Operation – Detailed Description:

System Startup: [from a fully de-energized state]

Pressing the **"Start"** button will cause the ***System Operational*** **indicators** on the control panels to **illuminate** and the **Safety Lights** to begin **flashing** ON/OFF at a frequency of ***f* = ½Hz** and with a **50% duty-cycle** (i.e. – **ON 1 sec ➡ OFF 1 sec ➡ repeat**). **Releasing** the "**Start**" button will cause no further changes.

(Note – the safety lights will continue flashing at all times with a 50% duty-cycle while the system is operational, although the frequency may change.)

Pressing the **"Start"** button a **2nd time**, holding it in for (at least) **1 second**, and then **releasing** the **button** will trigger the following set of ordered events:

a) The **Safety Lights** will begin flashing with at a frequency of ***f* = 1Hz**.
b) The **Safety Horn** will **sound** (ON) for **3 seconds**, **stop** (OFF) for **1 second**, and then **sound** again for **3 seconds**.
c) After the **Safety Horn** finishes sounding for the 2nd 3-second interval, the crucible held at the "in-cue" position on Conveyor #1 will begin move to the Loading Area.
d) Once the crucible is correctly positioned in the Loading Area, the **Safety Horn** will **sound** (ON) for **2 seconds**.
e) After the **Safety Horn** finishes sounding, the **Safety Lights** will begin flashing with at a frequency of ***f* = ½Hz**. At this time, the "***Startup***" process is complete and the system is considered to be in "***Normal Operation***".

Normal Operation:

During "***Normal Operation***", the system will operate as described as follows:

Conveyor #1 – Transport to and from the Loading Area

Transport from the Loading Area

When the crane operator finishes loading a crucible, he will **press** the "**Fill Complete**" button that is located on Control Panel #3 within the crane's control booth.

When "**Fill Complete**" is **pressed**, Conveyor #1 will **transport** the "**filled**" **crucible** to the "**In-Cue**" **position** on Conveyor #1, where it will be held until Conveyor #2 is ready to receive the "filled" crucible.

Note that the **correct positioning** for a **"filled" crucible** that is held "**In-Cue**" occurs when the crucible **initially breaks** the optical beam provided by **Optical Detector #2** (OD-2).

When Conveyor #2 is ready to receive the "filled" crucible, Conveyor #1 will then **transfer** the crucible from the "**In-Cue**" **position ➡ Conveyor #2**

Transport to the Loading Area

After an "**empty**" **crucible** is transferred from Conveyor #3 ➡ #2, it will immediately be transferred from Conveyor #2 ➡ #1, at which point Conveyor #1 will then **transport** the "**empty**" **crucible** back to the Loading Area, where it will be held until a "Fill Complete" signal is received from the crane operator.

The **correct positioning** for an "empty" crucible in the loading area occurs when the crucible **clears** (moves just past) the optical beam provided by OD-1.

Transport to the Arc Furnace

When Conveyor #2 receives a "**filled**" **crucible** from Conveyor #1, **Conveyor #2** will immediately **transport** the "**filled**" **crucible** into the melting chamber of the Arc Furnace.

The **correct positioning** for a "**filled**" **crucible** in the **melting chamber** occurs when the crucible **clears** the optical beam provided by **OD-4**.

Once the crucible is in-place, the **door** to the melting chamber will be **closed***, after which an "**Initiate Melting**" **signal** will be **sent** to the **arc furnace** and **held high until** a "**Melting Complete**" **signal** is **received**.

At this point (when door is closed), any "**empty**" **crucible** held "**In-Cue**" on Conveyor #3 will be transferred from "**In-Cue**" **position** ➞ **Conveyor #2** and then immediately from **Conveyor #2** ➞ **Conveyor #1**.

***** - Note that the melting chamber door should not be closed until the crucible present on Conveyor #3 is "empty" and held "in-cue" for transfer from Conveyor #3 ➞ #2 ➞ #1.

Transport from the Arc Furnace

When the arc furnace's "**Melting Complete**" **signal** is **received**, the chamber **door** will be **opened** and the **crucible** containing the molten steel will be **transported** to the **T-Junction** and then **transferred** immediately from **Conveyor #2** ➞ **Conveyor #3**.

Once the transfer is **complete**, Conveyor #2 is **ready** to receive another "**filled**" **crucible** from Conveyor #1.

CONVEYOR #3 – TRANSPORT TO AND FROM THE CASTING LOCATION

Transport to the Casting Location

When Conveyor #3 **receives** a **crucible** from Conveyor #2, it will immediately **transport** the crucible to the **Casting Location**.

The **correct positioning** for a **crucible** at the **casting location** occurs when the crucible **clears** the optical beam provided by **OD-6**.

When the crucible is in place, a "**Ready to Pour**" **signal** will be **sent** to the **casting machine**, at which time the pouring process will begin.

Transport from the Casting Location

When the pouring process is complete, the casting machine will return a "**Pour Complete**" **signal**, at which time the "**empty**" **crucible** will be **transported** to the "**In-Cue**" **position** on Conveyor #3, where it will be **held** until Conveyor #2 is ready to receive it.

ACTUATOR #1 – TRANSFER FROM CONVEYOR #2 ➞ #1 OR #3

Transfer from Conveyor #2 ➞ #1

When a **crucible** is ready to be transferred from **Conveyor #2** ➞ **Conveyor #1**, **Input A** of **Actuator #1** should be **triggered**, at which point the transfer will be initiated.

Note that **Input A** must be **held high** during the transfer process, and that adequate time must be allowed for the transfer to complete.

The **crucible** is known to be **completely transferred** into Conveyor #1 after **OD-2 clears**.

Transfer from Conveyor #2 → #3

When a **crucible** is ready to be transferred from **Conveyor #2 → Conveyor #3**, **Input B** of **Actuator #1** should be **triggered**, at which point the transfer will be initiated.

The **correct positioning** for a **crucible** that is to be **transferred** from Conveyor #2 → #3 occurs after the **crucible clears** the optical beam provided by **OD-3** and is completely seated on the end of Conveyor #2 at the **T-junction**.

Note that **Input B** must be **held high** during the transfer process, and that adequate time must be allowed for the transfer to complete.

The **crucible** is known to be **completely transferred** into Conveyor #1 after **OD-2 clears**.

ACTUATOR #2 – CLOSING/OPENING THE MELTING CHAMBER'S DOOR

Closing the Melting Chamber's Door

When the input to **Actuator #2** is **triggered**, the entrance **door** to the melting chamber will begin to **close**.

Note that the actuator's **input** must be **held high** in order for the door to **remain closed**. Adequate time must be allowed for the chamber door to fully close before the melting process is initiated. A **sensor** will **trigger** whenever the **door** is **fully closed**.

Opening the Melting Chamber's Door

The melting chamber's **door** will **automatically** begin to **open** whenever the **input** to **Actuator #2** returns to a "**low**" **state**.

Note that adequate time must be allowed for the chamber door to fully open before moving a crucible out of the melting chamber.

<u>System Shutdown</u>:

Pressing the "**Stop**" **button** will cause the following set of events (assuming that the system was initially operating normally):

a) The **Safety Lights** will begin flashing with at a frequency of $\boldsymbol{f}$ **= 1Hz**.
b) The **Safety Horn** will sound for **½-second** and then will continue to do so once **every 10 seconds until** the **shutdown** process is **complete**.

Additionally, pressing the "**Stop**" button will <u>also</u> cause the following events depending on the operational state of the system when the button was pressed:

State:

- <u>If there is a crucible in the **Loading Area**</u>, then the system will continue to operate "normally" until the crane operator presses either the "**Fill Complete**" or the "**Return Empty**" button.

- <u>If there are any crucibles that have been "**filled**" **but not** yet "**poured**"</u>, then the system will continue to operate until **every** "**filled**" **crucible** has been "**poured**".

- <u>If there is a crucible in the **Loading Area** and the "**Return Empty**" button is pressed</u>, then that **crucible** will **move** from the Loading Area **to** the "**In-Cue**" **position** on **Conveyor #1** and will it be held there until the shutdown process is complete. Note that this **crucible** is **considered** to be "**empty**".

- <u>If a crucible is being held at the "**In-Cue**" **position** on Conveyor #3 and there is **no crucible** on **Conveyor #1**</u>, then the crucible will **move** to the "**In-Cue**" **position** on **Conveyor #1** (after the melting process has begun for the crucible on Conveyor #2) and be held there until the shutdown process is complete.

- <u>If a **crucible finishes** "**pouring**" and there is already an "**empty**" **crucible** already being held at the "**In-Cue**" **position** on **Conveyor #1**</u>, then the **just-poured crucible** will **move** to the "**In-Cue**" **position** on **Conveyor #3**, at which point the following events will occur:
  - **a)** The **Safety Horn** will **sound** for **2 seconds**.
  - **b)** After the **Safety Horn** <u>finishes</u> sounding, the **Safety Lights** will shut **OFF**.
    The <u>shutdown process is complete</u>. The system has been "***shutdown normally***".

Note: If the "**Start**" **button** is pressed and **held-in for 2 seconds before** the **shutdown process** is **complete**, the **system** will **revert back** to **normal operation**, and any "**empty**" **crucible** on **Conveyor #1** will **move** back to the **Loading Area**.

<u>Emergency Stop</u>:

Pressing any of the **"Emergency Stop"** buttons will initiate the following set of ordered events:

a) <u>**All**</u> **conveyors** and **actuators** will immediately stop moving.
b) The ***Emergency Stop Indicator*** (on the panels) will illuminate.
c) The **Safety Lights** will begin flashing with a frequency of ***f*** **= 2Hz**.
d) The **Safety Horn** will pulse on/off continuously with a 50% duty-cycle and ***f*** **= 1Hz** for 10 seconds, after which it will sound for 1 second every 10 seconds until the "***Emergency Stop***" condition is cleared.

Note – the system will <u>remain</u> stopped until the "***Emergency Stop***" condition is cleared.

Clearing the "*Emergency Stop*" Condition

The operator can **clear** the "***Emergency Stop***" condition by pressing and holding-in <u>both</u> the "**Start**" and the "**Stop**" buttons <u>continuously for 3 seconds</u>, after which:

a) The **Safety Lights** will continue flashing with a frequency of ***f*** **= 2Hz**.
b) The ***Warning Buzzer*** will stop sounding.

Restarting the System after the "*Emergency Stop*" Condition has been Cleared

The operator can "**restart**" the **system** by **pressing and holding-in** the "**Start**" **button** <u>continuously for 3 seconds</u>. This will cause the following set of events:

c) The **Safety Lights** will begin flashing with a frequency of ***f*** **= ½Hz**.
d) The **Safety Horn** will **sound** (ON) for **3 seconds**, **stop** (OFF) for **1 second**, and then **sound** again for **3 seconds**.

After the **Safety Horn** <u>finishes</u> sounding for the 2nd 3-second interval, the **rest** of the **restart process** will **depend** on the **state** of the **system** when the Emergency Stop was initiated:

State:

- <u>If any crucible had been "melted" completely but not yet "poured" completely</u>, then the system must be reversed in order to re-melt that crucible:
  - **a)** If the "other" crucible is on Conveyor #2, then that crucible must first be moved back to the In-Cue position on Conveyor #1.
  - **b)** The completely "melted" crucible will then be moved back to the Arc Furnace and the melting process will be re-initiated. At this point, the system is considered to be in "***Normal Operation***".
- <u>If a crucible had been partially "melted" and is still located in the Arc Furnace</u>, then the melting process can simply be re-initiated. At this point, the system is considered to be in "***Normal Operation***"
- <u>If no crucible had been partially or completely "melted" but not yet "poured"</u>, then the system is considered to be in "***Normal Operation***"

Challenge Task – Motor Overload:

This section may be added soon.

POWER AND OPERATIONAL REQUIREMENTS OF THE SYSTEM DEVICES:

Conveyors/Motors:

All three conveyors will be driven by 3Φ, 460V, 60Hz, 10hp, Y-connected, Squirrel-Cage Induction Machines. The conveyors will come preconfigured with their associated drive motors, but all additional equipment (contactors, VFDs, etc.) required to supply and/or to control the drive motors must be specified as part of your system design.

Conveyor #1 needs to be able to operate at variable speeds in both the forward direction and the reverse direction. For this reason, a VFD will be used to supply the conveyor's drive motor. Further details about the speed requirement are provided later in this document.

Conveyor #2 needs to be able to operate at a single speed in both the forward direction and the reverse direction. Thus, a contactor-based supply for its drive motor should be utilized.

Conveyor #3 needs to be able to operate at a single speed in both the forward direction and the reverse direction. Thus, a contactor-based supply for its drive motor should be utilized.

Actuators:

Actuator #1 controls the transfer of the crucibles from Conveyor #2 to either Conveyor #1 or Conveyor #3. The ratings of the actuator are 1Φ, 120V, 60Hz, 5A, and it is triggered by the application of a $24V_{DC}$ signal voltage to one of its two inputs. Note that this actuator returns to center position when neither input receives a $24V_{DC}$ signal voltage.

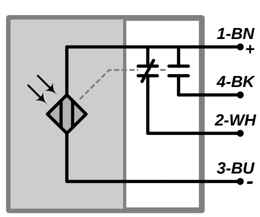
Actuator #2 controls the door at the entrance of the Melting Chamber. The ratings of the actuator are 1Φ, 120V, 60Hz, 10A. The door is closed by the application of a $24V_{DC}$ signal to the actuator's input. Note that the door will automatically open when the $24V_{DC}$ signal is removed from the input, but that care must be taken to ensure the door is completely open before a crucible is moved out of the chamber.

Variable Frequency Drive:

The VFD utilized within the system will be a 3Φ, 460V, Allen-Bradley, PowerFlex 40 drive.

Optical Detectors:

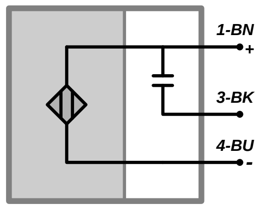
The **Optical Detectors** are beam-type detectors that trigger when an object breaks their light-beam. The detectors require a $+24V_{DC}$ supply for operation and contain a NO/NC contact pair that actuate when the detector is triggered. The NO contacts will be connected to the PLC's inputs such that the inputs will go "high" whenever an object is detected.



Optical Detector Ratings:
$V_{rated} = 10\text{–}36V_{DC}$
$I_{rated} \leq 20mA_{DC}$
$I_{switching} \leq 200mA_{DC}$

<u>Door Sensor</u>:

The **Door Sensor** is a capacitive-type proximity sensor, the sensitivity of which can be adjusted to trigger when a metallic object is in close-proximity to the sensor. The sensor requires a $+24V_{DC}$ supply for operation and contains a NO contact that actuates when the sensor is triggered. The NO contact will be connected to the PLC's input such that the input will go "high" whenever a metallic object is detected.



Proximity Sensor Ratings:
V_{rated} $= 10–60V_{DC}$
I_{rated} $\leq 400mA_{DC}$

<u>Oven Door Actuator</u>:

Details will be added soon.

<u>T-Junction Actuator</u>:

Details will be added soon.

Calendar / Deadlines / Milepost Requirements: (This Section is Still Being Revised)

March 10th (Tuesday) – Group Selection – 8pm

The names of the members of each group must be submitted by 8pm (the beginning of lecture). Any students who are not in a three-person group by the end of class will be assigned randomly into the two-person groups.

March 17th & 19th (Tues/Thurs) – 5pm-7^{30}pm – Electrical System Review – Group Meetings

March 26th (Thursday) – 8pm – Electrical System Design & Documentation Due

A complete, computer-drawn, **schematic diagram** must be submitted to the instructor by **9:30am** (the beginning of lecture). The drawing should clearly show all of the electrical power and control devices utilized within system, including the actuators, and all of the motors, contactors, overload relays, VFDs, PLCs, pushbuttons, optical detectors, indicators, power supplies, and other devices required for proper system operation.

An **equipment schedule** must also be included with the schematic diagram that lists all of the devices utilized as part of the electrical system. The equipment schedule should provide all of the ratings of the electrical devices along with any other information about the devices (specifications, settings, etc.) that would be required for proper system setup/operation.

Note that the submitted schematic diagram and equipment schedule, and a complete wiring diagram (that is not due on the 26th) must also appear in the final written report.

April 16th (Thursday) – 8pm – Exam II

April 23th (Thursday) – Draft of Final Report (Optional Milepost)

Although not required, it is highly recommended that an initial draft of the formal report be completed by **8pm** so that it can be informally presented to the instructor for comment.

April 27th-29th (Mon/Tues/Wed) – By Appointment – Individual Project Meetings

April 28th (Tuesday) – 4pm – System Demonstration (Software)

Each group must have demonstrated the correct operational function of their system by **4pm**.

Note that 4pm deadline does **NOT** mean that you can demo your system AT 4pm. Individual meetings will also be happening that day, so plan on having your coded system **ready-to-go by noon** to ensure being able to demonstrate its operation **before** the **4pm deadline**.

April 30th (Thursday) – 5pm – Final Report Submission

The final report for this project must be submitted as both as a "**formal**", (electronically-generated) **printed document** AND as a single **computer file** (Word or PDF) by **5pm**.

The report must either be either handed directly to the course instructor or turned into the administrative assistant in the departmental office.

Note that the submitted reports are kept on file for accreditation purposes and will not be returned to the project groups. Thus, it is highly recommended that each group member independently keep a copy of their report for portfolio purposes.

Final Report Guidelines and Expectations: **(Note – this section may be updated before 04/18)**

GENERAL REQUIREMENTS:

Only one report will be submitted by each group.

The final report for this project must be submitted as a "**formal**", electronically-generated and printed document that is either bound together with a protective cover or secured within a thin, three-ring binder. (Do **NOT** just staple the pages together)

The cover page of the report should contain the full name of each project-team member.

The report should be well organized, and it should contain a detailed and well formatted:

- **Table of Contents**
- **List of Figures**
- **List of Tables**

in order to help a reader easily locate any specific material presented within the report.

See: (link to be provided)
for an example of a well-formatted Table of Contents. Although a different layout and/or numbering scheme may be chosen for the report, take note of the attention to detail shown in the sample document in terms of the consistency, spacing, and alignment.

For example – the section and subsection headings follow a consistent layout, numbering, and font scheme, and all of the page numbers shown are aligned vertically.

A similar attention to detail should be apparent throughout the entire report:

– The report should be well organized and broken down into logical sections,

– The layout and font scheme should be consistent from section to section,

– All pages should be sequentially numbered, and

– All figures/tables should be given appropriate titles along with sequential figure/table numbers.

IMPORTANT NOTES:

- The main purpose of the report is to document the work that you have completed. It is **not** meant to instruct or teach the readers how to design or program the system themselves. Thus, do **NOT** explain things like how an optical detector works, how an On Delay Timer (TON) works, etc. Additionally, although it may be worthwhile to state and briefly discuss the software that is required for proper operation of the designed system, do **NOT** discuss in-detail how to configure and operate those programs (BootP, RSLinx, RSLogix).
- The report should contain a complete, concise description of the designed system, including its physical components, its overall operation, the operation of its sub-systems, and the software (logic) used to control the system. Do **NOT** just copy the text sections from this document and paste them into your report; instead, put them in your own words and summarize them.
- The scale-model conveyor system in the laboratory was provided solely for the purpose of testing and troubleshooting the automation software that is required as part of this project. Although it would be logical to briefly present this system as part of the software design process discussion, the scale-model system should **NOT** be a primary focus of the overall report.

Formal Report Guidelines and Expectations: (CONTINUED):

SPECIFIC REQUIREMENTS:

The following (or similar) sections should appear within your report in the order shown:

- **Introduction**
- **Project Description**
- **Conveyor System Description**
- **Electrical System Design**
- **Software Design**
- **Appendix**

PROJECT DESCRIPTION:

The key aspects of the **design project** should be summarized within this section, beginning with a brief discussion of the proposed conveyor system, followed by a discussion of the specific design tasks (hardware and software designs) that are required as part of this project.

Additionally, any portions of the proposed system and/or design tasks that were deemed "outside the scope" of this project should also be summarized within this section.

For example – the design and operation of the arc-furnace is "outside the scope" of this project such that only the signal lines to and from EAF were required as part of the electrical system design. Note that proper coordination with the EAF's operation is required as part of the software design.

CONVEYOR SYSTEM DESCRIPTION: (This Section is Still Being Revised)

A detailed presentation of the proposed system should appear in this section, beginning with a discussion of the key aspects of the system. This discussion should include the overall layout of the complete system and the general operational logic of the system (startup, normal operation, etc.).

The overall operational procedures, from an "operator's" point of view, should also be presented. This should include a discussion of the various control panels provided throughout the system.

Additionally, a set of simplified set of **operational flow-charts** should be provided within this section that depicts the overall operation of the system from the perspective of the "operator". The flow charts should include "System Startup", "Normal Operation", "System Shutdown", and "Emergency Stop".

An in-depth discussion of the conveyor subsystems should follow the presentation of the overall system. Both the hardware requirements and the operational logic of the subsystems should be presented.

Although the "logic" tables provided within this handout should appear in the Appendix of the report, do **NOT** simply copy-and-paste them into this section. The logic tables are primarily based on the "Status Bits" and the Optical Detectors, which would most likely confuse the reader. Instead, summarize the logic tables or provide a set of flow charts based on function.

For example: Conveyor #2 Operational Logic

- When a tray reaches OD-4, the door will open.
- Two seconds after OD-4 clears, the door will close…

SPECIFIC REQUIREMENTS (CONTINUED):

ELECTRICAL SYSTEM DESIGN: (This Section is Still Being Revised)

The design of the electrical system will be discussed within this section.

The discussion should begin by focusing on the system requirements based on the required design specifications presented within this document, including the provided Input/Output Schedule for the PLC.

Next, the proposed design should be presented and discussed. This should include any arbitrary decisions that were made during the design process along with justifications of those decisions. Both a **schematic diagram** and an **equipment schedule** are required for documentation of the proposed design.

The Schematic Diagram is used to depict the electrical system from an operational standpoint. Thus, the diagram must show all of the electrical power and control devices utilized by the proposed coating system including both the primary devices specified in this document and any auxiliary devices (contactors, etc.) that are required to build the system. The diagram must be electronically-generated, logically organized, completely labeled, and contain a legend for all of the symbols used within the diagram.

Components should be logically laid out and grouped together based upon their function. For example, all of the "power" components, such as the electric motors and the directly-connected components (overload relay heaters, main contacts) should be grouped together in the same area of the diagram.

Additionally, each component should be clearly labeled with a unique identifier, such as "IM-1" for the induction motor that will be used to drive conveyor #1, or "OL-2" for all of the components (heaters, NO contact) that are contained in the specific overload relay that will be used to protect induction motor #2.

The equipment schedule is an organized and tabulated listing of all of the components utilized within the electrical system (i.e. – shown in the schematic diagram). A different row of the table should be utilized for each unique component, beginning with the component's unique identifier(s) followed by the required number of that component. Additionally, the name of the component and a description of the component (ratings, etc.) should be provided, along with any other important information that would be required in order to purchase all of the system components.

SOFTWARE DESIGN: (This Section is Still Being Revised)

The design of the software used to control the system will be discussed within this section.

The discussion should begin with an overall description of the ladder-logic program created for the PLC, focusing on the overall layout or structure of the program. Key aspects of the program's structure should be highlighted, such as the use of "status bits" to govern the operation of the system.

A complete printout of the actual software (**ladder-logic program**) should be provided in this section. The diagram should be fully commented such that all elements contained with the program are logically described.

Additionally, a tabulated list of names and descriptions should be provided for all of the base tags (status bits) and all of the alias tags that you created.

Formal Report Guidelines and Expectations: (CONTINUED):

APPENDIX:

The appendix should contain any technical or reference information pertaining to the system that was not presented in the above-mentioned sections, such as the detailed logic tables provided in this document that define the require operation for the three conveyors.

OTHER REPORT COMPONENTS:

The "general" and "specific" requirements stated above are **not** to be considered the only requirements for the final report. The report is a formal document that should cover **all** aspects of this project, focusing on the overall design and operation of your system while also providing any other information required or typically included in such a report.

Note – the overall report **quality (thoroughness, organization, etc.)** will be heavily considered when assigning a score to the "Report" portion of the Final Project grade.