MINUTES OF THE CEMA ENGINEERING CONFERENCE
CONVEYOR CONTROLS COMMITTEE MEETING
Tuesday, June 27, 2017

1. Meeting called to order at 1:00 pm – Robert Gruendel, Dematic.

2. Attendance and introductions

3. Current agenda – approved

4. Review and approval of previous minutes – approved

5. Old Business
   a) E-Stop Best Practice Guide – Final Update:
      - SBP-002 (2016) - E-Stop Application Guide for Unit and Bulk Material
        Handling Conveyor Systems, was published in September 2016.
      Sub-Committee: Rick Uchtman, Intelligrated, Inc.; Robert Gruendel, Dematic;
      Johnny Wheat, 4B Components Ltd.; Andrew Jennings, Conveyor Dynamics Inc.
      - How to score risk? 12 people like ISO/IEC standard, 0 people think basis
        should be ANSI.
      - Note: Ask Frank Loeffler, Loeffler Engineering Group about CEMA risk
        assessment scoring development.

6. New Business
   a) Retrofit/Refurbishment Best Practices Guidelines related to safety related
      control systems
      Sub-Committee: Robert Gruendel & Dan Modzeleski, Dematic; Rick Uchtman,
      Intelligrated, Inc.; Andy Eckerle, Bastian Solutions; Andrew Jennings, Conveyor
      Dynamics Inc.
      - Refurbishment vs. Retrofit: An example of refurbishment is a replacing motor
        and shouldn’t need safety system upgrade. An increase in conveyor speed
        may need a safety system upgrade.
      - Replacing obsolete hardware vs. Adding hardware: If you are affecting the
        safety related control system, you need to update the safety related control
        system.
      - There is interest from the committee in the creation of this document.
   b) NFPA 79 2021 proposed revisions
      - Public inputs are suggestions to modify standard
Robert Gruendel, Dematic, explained the NFPA revision process. CEMA committee agreed to support specific public inputs to NFPA 79, which are beneficial to their organization. CEMA task group will review and make a presentation explaining to the CEMA controls committee as to why this is beneficial to your company. Individuals from CEMA manufacturers will submit Public Inputs, submit comments (for or against) revision changes, and vote.

c) Call for new business. No new business were suggestions made.

7. Election of Chair / Vice Chair
   a) Change of Chair Term. Vote to change Controls Committee Chairmanship term from 3 years to 2 years. Passed
   b) Election of Vice Chair. William Brungs, Intelligrated Inc. elected vice chair; Andrew Jennings, Conveyor Dynamics Inc. is now chairman.

8. Next Meeting: June 26, 2018 at La Playa Hotel, Naples, FL.

9. Meeting adjourned at 2:03 pm

Respectively submitted,

Robert Gruendel

CEMA Conveyor Controls Committee
## Conveyer Controls Committee Meeting Roll Call - June 27

<table>
<thead>
<tr>
<th>Company</th>
<th>Name</th>
<th>New Member</th>
<th>First Mtg</th>
<th>E-mail</th>
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<tbody>
<tr>
<td>4B Components Ltd.</td>
<td>Johnny Wheat</td>
<td></td>
<td></td>
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<td>Bastian Solutions</td>
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<tr>
<td>Bastian Solutions</td>
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<td>✓</td>
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<tr>
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<td>Sharath Srikanth</td>
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<tr>
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<tr>
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<tr>
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<td>CEMA</td>
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<tr>
<td>Conveyor Dynamics, Inc.</td>
<td>Andrew Jennings</td>
<td></td>
<td></td>
<td><a href="mailto:jennings@conveyor-dynamics.com">jennings@conveyor-dynamics.com</a></td>
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<tr>
<td>Dematic</td>
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<td>Dematic</td>
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## Safety Control System Design Guide - Revision

**Draft 24**  
Chair: Robert Gruendel

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### DRAFT HISTORY

<table>
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<tr>
<td>Draft 1 – Original Document</td>
<td>June 1, 2017</td>
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<tr>
<td>Draft 2 – Added objectives</td>
<td>June 7, 2017</td>
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Conveyor Equipment Manufacturers Association (CEMA)

Safety Best Practices Recommendation
CEMA SBP-??? (2017)

Safety Control System Design
For
Unit and Bulk Material Handling
Conveyor Systems

Provided as a service to the Conveying Industry
By The
CEMA Engineering Conference
Conveyor Safety Committee

Original Publication Date: 2017
DISCLAIMER

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This document shall be used in conjunction with the applicable current standard of ASME b20.1 “Safety Standard for Conveyor and Related Equipment.”

CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION
5672 Strand Court, Suite 2
Naples, Florida 34110
Web Site: http://www.cemanet.org

CEMA Safety Control System Design Best Practices Recommendation (SBP) No. ???-2017 - Copyright 2017
1 Definitions

2 Objectives

The following objectives form the basis toward which we must strive in safety control system design. Occasionally, these objectives must be tempered with the realities of practical application such as equipment density, equipment interfaces, and customer operational preferences, which can be evaluated using established risk assessment methods.

- Reduce the speed or stop the conveyor motion when a safety event occurs in order to prevent or minimize accidents that may result in injury to personnel, damage to equipment or damage to conveyables.
- Prevent the restart or return to normal speed before the safety event has been eliminated.
- Prevent the generation of other hazards by the safety system reaction after a safety event occurred.

3 Hazard Risk Assessment

The process of assessing hazards should begin with the safeguards removed. The hazards are identified in the original designed state. The hazards must be assigned a severity, probability of avoidance, and frequency of exposure to personnel. There are many risk assessment methods and none can claim to be the only way to perform one. It is a basic requirement that risk assessments be performed by a committee. Ideally this committee is made up of all disciplines which will be exposed to the hazards. This allows for various perspectives to be shared and compromise to be reached as to the grading.

4 Determination of PLr

Determination of the PLr from Risk Assessments:

The required performance level to be met by a system is determined by the priority index obtained from the Risk Assessments performed on the product. Below are some reference tables showing how the risk is estimated and priority index is calculated. Also these show the translation of priority index to the PLr, Functional Performance Requirements for Safeguards Utilizing SRP/CS

The control system elements responsible for the safety function are considered the safety-related parts of the control system (SRP/CS).

The information is with reference to the standard ISO 13849-1 Safety of Machinery - Safety-related parts of a control system

Section 4.3 Determination of required performance level (PLr) as mentioned in ISO 13849-1 says that: For each selected safety function to be carried out by a SRP/CS, a required performance level (PLr) shall be determined and documented. The determination of the required performance level is the result of the risk assessment and refers to the amount of the risk reduction to be carried out by the safety-related parts of the control system. The greater the amount of risk reduction required to be provided by the SRP/CS, the higher the PLr shall be.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Rating</th>
<th>Criteria (Examples)</th>
</tr>
</thead>
</table>
| Injury Severity | Serious S3 | Normally non-reversible:  
- Fatality  
- Limb Amputation  
- Long Term Disability  
- Chronic Illness  
- Permanent Health Change  
If any of the above are applicable, the rating is SERIOUS. |
| Moderate S2 | Normally Reversible:  
- Broken Bones  
- Severe Laceration  
- Short Hospitalization  
- Short Term Disability  
- Loss Time (multi-day)  
- Finger Tip Amputation (not thumb)  
If any of the above are applicable, the rating is MODERATE. |
| Minor S1 | First Aid:  
- Bruising  
- Small Cuts  
- No Loss Time (multi-day)  
- Does not require attention by a medical doctor  
If any of the above are applicable, the rating is MINOR. |
| Exposure | High E2 | - Typically more than once an hour  
- Frequent or multiple short duration  
- Duration/situations which could lead to task creep and does not include teach.  
If any of the above are applicable, the rating is HIGH. |
| Low E1 | - Typically less than or once per day/shift  
- Occasional short durations  
If any of the above are applicable, the rating is LOW. |
| Avoidance | Not Likely A2 | - Insufficient clearance to move out of the way  
- Inadequate warning/reaction time  
- Hazard is moving faster than 250 mm/s (10 in/s)  
- May not perceive the hazard exists  
If any of the above are applicable, the rating is NOT LIKELY. |
| Likely A1 | - Sufficient clearance to move out of the way  
- Adequate warning/reaction time  
- Hazard is moving at or less that 250 mm/s (10 in/s)  
If any of the above are applicable, the rating is LIKELY. |

Table 1 – Hazard Risk Estimation
Table 2 – Risk Reduction Matrix

<table>
<thead>
<tr>
<th>Severity of Injury</th>
<th>Exposure</th>
<th>Avoidance</th>
<th>Risk Reduction Priority</th>
<th>Safeguarding Measures</th>
<th>Functional Performance Requirements for Safeguards Utilizing SRP/CS</th>
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<tbody>
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<td>S3 Serious</td>
<td>E2</td>
<td>A2</td>
<td>Not Likely</td>
<td>PR1 HIGH</td>
<td>Risk Reduction by Safeguarding</td>
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<tr>
<td></td>
<td>E1</td>
<td>A1</td>
<td>Likely</td>
<td></td>
<td>Fixed guard preventing access; engineering controls preventing</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td>access to the hazards, e.g. interlocked guards, light curtains,</td>
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<td>safety mats, or other sensitive protective equipment</td>
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<td>implemented to meet a functional safety performance</td>
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<tr>
<td>S2 Moderate</td>
<td>E2</td>
<td>A2</td>
<td>Not Likely</td>
<td>PR2 MEDIUM</td>
<td>Risk Reduction by Safeguarding</td>
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<td>Inherently safe design measures</td>
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<td>Hazard elimination or hazard substitution</td>
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<td>Complimentary protective measures</td>
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<td>Non-interlocked guards, clearance, procedures and equipment</td>
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<td>implemented to meet a functional safety performance</td>
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Table 3 - Safeguard Selection

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<th>Avoidance</th>
<th>Severity of Injury</th>
<th>Risk reduction Priority</th>
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<td>A2</td>
<td>S3 Serious</td>
<td>PR1</td>
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<td>A1</td>
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<td>PR2</td>
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<td></td>
<td>S1 Minor</td>
<td>PR3</td>
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<td>S3 Serious</td>
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<td>PR3</td>
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<td>A1</td>
<td>S3 Serious</td>
<td>PR4</td>
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<td></td>
<td>S2 Moderate</td>
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<tr>
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<td></td>
<td>S1 Minor</td>
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Section 4.3 in ISO 13849-1 also says that:
When a safety-related control function is designed, each SRP/CS shall be designed either according to this part of ISO 13849 or according to IEC 62061/IEC 61508. Therefore, protective measures to reduce the risk shall be applied, principally the following.

— **Reduce the probability of faults at the component level.** This can be done by increasing the reliability of components, e.g. by **selection of well-tried components** and/or applying well-tried safety principles, in order to minimize or exclude critical faults or failures (see ISO 13849-2).

— **Improve the structure of the SRP/CS.** The aim is to avoid the dangerous effect of a fault. Some faults may be detected and a **redundant and/or monitored structure could be needed**. Both measures can be applied separately or in combination. With some technologies, risk reduction can be achieved by selecting reliable components and by fault exclusions; but with other technologies, risk reduction could require a redundant and/or monitored system. In addition, common cause failures (CCF) shall be taken into account.

### 5 Risk Reduction

Once the risk assessment is obtained and the PLr is determined, various strategies could be implemented for the reduction of risk, thus in turn reducing the risk reduction priority.

Section 4.2: Strategy for risk reduction in ISO 13848-1 says that:

The hazard analysis and risk reduction process for a machine requires that hazards are eliminated or reduced through a hierarchy of measures:

- Hazard elimination or risk reduction by design (see ISO12100:2010, 6.2);
- **Risk reduction by safeguarding and possibly complementary protective measures** (see ISO 12100:2010, 6.3);
- Risk reduction by the provision of information for use about the residual risk (see ISO 12100:2010, 6.4).

Section 6: Risk Reduction in the standard ISO 12100 Safety of Machinery - General Principles for design - Risk assessment and risk, provides some guidelines on what could be used as part of risk reduction techniques.

6.1 Safeguarding and/or complementary protective measures:

Taking into account the intended use and the reasonably foreseeable misuse, appropriately selected safeguarding and **complementary protective measures can be used to reduce risk when it is not practicable to eliminate a hazard, or reduce its associated risk sufficiently, using inherently safe design measures.**

This following section provides the performance requirements of the control systems

6.2.11.7 Safety functions implemented by programmable electronic control system:

Where a programmable electronic control system is used, it is necessary to consider its performance requirements in relation to the requirements for the safety functions. **The design of the programmable electronic control system shall be such that the probability of random hardware failures and the likelihood of systematic failures that can adversely affect the performance of the safety-related control function(s) is sufficiently low.** The programmable electronic control system should be installed and validated to ensure that the specified performance [for example, safety integrity level (SIL) in IEC 61508] for each safety function has been achieved.

The following section gives guidelines on design of safety related parts.
6.2.12.4 Duplication (or redundancy) of components or subsystems
In the design of safety-related parts of the machine, duplication (or redundancy) of components may be used so that, if one component fails, another component or components continue to perform the respective function(s), thereby ensuring that the safety function remains available.
In order to allow the proper action to be initiated, component failure shall be detected by automatic monitoring (see 6.2.11.6) or in some circumstances by regular inspection, provided that the inspection interval is shorter than the expected lifetime of the components. Diversity of design and/or technology can be used to avoid common cause failures (for example, from electromagnetic disturbance) or common mode failure

6 Safety Control System

For the use of control system as part of risk reduction, the electrical control system(s) shall have an appropriate performance that has been determined from the risk assessment of the machine. This is stated in the section 9.4 Control functions in the event of failure, of standard IEC 60204 Safety of Machinery – Electrical Equipment of Machines. Section 9.4 states that:
Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the machine or to the work in progress, appropriate measures shall be taken to minimize the probability of the occurrence of such failures or disturbances.

The following is a non-inclusive list of terms: Risk reduction measures (Supplier and User) found in ANSI B11.19. Note: The entity who is typically responsible for the risk reduction measures shown below appears in (brackets).
1. Inherently safe design measures (supplier).
2. Safeguarding/Safeguards (supplier and user).
3. Complementary equipment and measures (supplier):
   - Emergency stop devices (palm / push buttons or rope / cable pulls);
   - Stopping performance monitor;
   - Process malfunction detection and monitoring equipment;
   - Safety interface (safety relay) modules;
   - Safety PES / PLC, safety controllers (including the safety - bus systems);
   - Enabling devices;
   - Measures for isolation and energy dissipation;
4. Information for use (supplier and user):
5. Organizational (User)
6. Personal Protective Equipment (User)
7. Training (User)

ANSI B11.0 Safety of Machinery: The design of control systems performing a safety function shall comply with the principles and methods presented in 7.2.1. Section 7.2.1 says that:
The design and performance of the safety - related parts of the control system (SRP/CS) shall be commensurate with the risk reduction provided by the safety function
Examples of methods used to increase reliability in designing SRP/CS include one or more of the following:
- Certified components or systems suitable for the application;
- Fail-to-safe components or systems;
• Redundant components or systems;
• Diverse components or systems;
• Equipment and devices with an appropriate probability of failure on demand (PFD) and safe failure fraction (SFF) (For additional information, see IEC 61508);
• Automatic monitoring (For additional information, see IEC 62061)

ANSI B11.19 Performance Criteria for Safeguading: Annex G: Safeguarding Flowchart (For Complementary Equipment) shows how complementary measures could be used as part of risk reduction techniques and change the performance level required (PLr) once the measures are incorporated into the design of the system.

Annex C: Performance of the safety-related function(s)
Control reliability is a design strategy, method or feature that separates the safety-related functions of a system into components, modules, devices or systems that can be monitored or checked by other components, modules, devices or systems.
The use of redundant components, modules, devices or systems (with or without monitoring or checking) is used where the goal is to maintain the process in the event of a failure.

7 Safety Control System Design

From the Risk Assessments provided by a third party vendor, recommended Performance level/Functional requirements for safeguards were obtained. The solutions were applied (inherently safe design measures/ safeguarding) and the priority index after safeguard selection is indicated. As per those priority indexes after referencing to the table: Risk decision Matrix, the Performance level required is determined.

For the products that Risk Assessment have been completed by third party vendor, following are the recommendations: (Taking the worst case scenario in each list)

<table>
<thead>
<tr>
<th>Priority Index</th>
<th>Conveyor Type</th>
<th>PLr for Functioning of Control System</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR1</td>
<td>Shoe Sorter</td>
<td>PL - d</td>
</tr>
<tr>
<td>PR2</td>
<td>Strip Belt</td>
<td>PL - d</td>
</tr>
<tr>
<td>PR3</td>
<td>MDR Transfer</td>
<td>PL - c</td>
</tr>
<tr>
<td>PR4</td>
<td>any other conveyor section</td>
<td>PL - b</td>
</tr>
</tbody>
</table>

To achieve the Performance Level required as recommended by the Risk Assessments, complementary equipment can be used as risk reduction measures. As mentioned in above sections in reference to the standards document, the following complementary measures are designed as part of Fieldbus Safety design:

• Emergency stop devices (palm / push buttons or rope / cable pulls);
  Inputs from each pull cord switch are connected to dual channel of Safety Input card
• Process malfunction, detection and monitoring equipment;
  Safety PLC/ Controller will be able to detect any wiring faults and also the redundancy of the E-Stop circuitry inputs reduces single fault failure cases.
• Safety interface (safety relay) modules;
The existing motor starter relays will be replaced with safety relays. Inputs and outputs related to these relays will be coming off from Safety I/O cards to have malfunction detection and equipment monitoring

- Safety PES / PLC, safety controllers (including the safety - bus systems);
- Safety PLC Controller will be used in place of a regular PLC controller. Safety I/O cards are used giving us additional monitoring capability of fault detection

Complementary protective measures (Field bus Safety Design) are used to reduce risk because it is not practicable to eliminate the hazard, or reduce its associated risk sufficiently, using inherently safe design measures on our conveyor systems.

These design changes could be considered while evaluating the risk reduction measures. As per Section 4.3 in ISO 13849-1 mentioned earlier, well tried/ Safety Rated components have been selected. Thus this reduces the probability of faults at the component level. Also as redundant circuit is designed for E-Stops, the structure of SRP/CS is improved.

As per Section 6: Risk Reduction in the standard ISO 12100, these complementary protective measures can be used to reduce risk and sufficient enough if they are meeting the PLr recommended in the Risk Assessments. The new Field bus Safety design is such that the probability of random hardware failures and the likelihood of systematic failures that can adversely affect the performance of the safety-related control function(s) is sufficiently low. This is because:

1. Redundancy of components is used
2. Component/wiring failure is detected by automatic monitoring

8 Conclusion

From the Risk Assessments obtained and the recommendation from those, PLr required by each conveyor section is determined. Necessary complementary measures were designed as per the Recommended PLr for each conveyor type/section.

9 References

- ANSI B11.0 Safety of Machinery
- ANSI B11.19 Performance Criteria for Safeguarding
- ISO 13849-1 Safety of Machinery - Safety-related parts of a control system
- ISO 13850-1 Safety of Machinery – Emergency Stop Function - Principles for design
- ISO 12100 Safety of Machinery - General Principles for design - Risk assessment and risk
- IEC 60204 Safety of Machinery – Electrical Equipment of Machines