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Pascal Poisson, Yuvin Chinniah, Sabrina Jocelyn



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Design of a Safety Control System to Improve the Verification Step in Machinery Lockout Procedures: A Case Study

Pascal POISSON, Yuvin CHINNIAH, Sabrina JOCELYN
 POLYTECHNIQUE MONTRÉAL, MATHEMATICS AND INDUSTRIAL ENGINEERING
 DEPARTMENT C.P. 6079, Succursale Centre-ville, Montreal (Quebec), H3C 3A7, CANADA
 ppoisson@interventionprevention.com

Abstract –

In Canada and other industrialized countries, workers who are required to carry out tasks in the danger zone of a machine when performing repairs, maintenance or unjamming activities must follow lockout procedures, unless safe alternative methods exist and can be applied. The verification step in lockout procedures is often neglected by workers for various reasons. This paper presents the design process for a new, reliable safety control system for the verification step. The design will allow automatic verification of zero electrical energy in the machine. Consequently, little effort will be required by workers to carry out this important step in the lockout procedure. Moreover, energy-saving systems create additional difficulties for lockout. This case study involves a paperboard extruder used to apply plastic on paperboard. It uses a DC bus that links the speed drives together as an energy-saving measure. This paper details for the first time the design and validation steps specified in ISO 13849-1 and 2 when using a programmable safety control system to improve the lockout verification step. The approach adopted here can be used for other machines and will help improve worker safety during interventions by ensuring correct application of the lockout procedure. The system described here was designed prior to publication of the 2015 version of ISO 13849-1. Accordingly, it was designed in compliance with the 2006 version of this standard, which directly preceded the 2015 version.

Keywords – Lockout; Maintenance; Machine; ISO 13849; Safety

1. Introduction

Industrial machines are known to pose multiple hazards. Different types of machinery hazards are identified in standards ISO 12100 [1], CSA Z432 [2], and ANSI B11-TR3 [3], and in a large volume of literature. For example, Bluff (2014) [4] lists hazards associated with machinery. Workers intervene on machinery in all phases of its life cycle, i.e. installation, operation, maintenance, troubleshooting, repairs, adjustments, set-up, handling production disturbances, cleaning and dismantling. As such, they are exposed to hazards. Machines cause many accidents in the workplace. For the years 2003 to 2010, 5,579 occupational machine-related fatalities were caused by machinery in the US (Marsh et al., 2015) [5]. The Bureau of Labor Statistics in the US (US Bureau of Labor Statistics, 2014) [6] revealed that a total of 717 fatal work injuries occurred as a result of contact with objects and equipment in 2013. Great Britain's Health and Safety Executive (HSE) reports that 50% of accidents in 2003 and 2004 related to moving parts of machines in the UK involved printing presses and conveyors (HSE, 2006) [7]. Bulzacchelli et al. (2008) [8] report that just over 1,000 (i.e. 18%) of workers fatally injured in the US in 2005 were in contact with objects and equipment. Bellamy et al. (2007) [9] report that about 400 accidents annually, i.e. 21% of total accidents per year in the Netherlands, are caused by contact with moving parts of machinery. Gardner et al. (1999) [10] report that in Australia, mechanical equipment injury may account for 28% of all compensation injuries. Gerberich et al. (1998) [11] report agricultural machinery as a principal source of non-fatal injuries in the rural sector in the United States. Chinniah (2015) [12] analyzed 106 reports concerning accidents related to moving parts of machinery that occurred in the province of Quebec, Canada, and found that many accidents occurred during maintenance and the handling of production disturbances, when the operator entered a danger zone around the machinery. A mechanical hazard was already present (e.g. rotating shafts) or appeared suddenly (e.g. blade started rotating suddenly). The Chinniah study found that 12.3% of accidents were linked to the set-up phase, 19.8% to production tasks, 34.9% to maintenance tasks and 31.1% to handling production disturbances. The main causes of machinery-related accidents are easy access to moving parts of machinery, lack of safeguards, worker inexperience, bypassing of safeguards,

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