

OPERATOR'S MANUAL INSPECTION

for the Safety Professional

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THE FOCUS OF THIS ARTICLE is an examination of the issues in operator's manuals that contribute to unsafe use of machinery, using agricultural and earthmoving heavy equipment as examples. Many incidents leading to injury or death occur with the improper operation of machinery. OSHA defers to operator's manuals when no specific standard covers the machinery or operation involved, which falls under the General Duty Clause of the OSH Act. Analysis of incidents presents various safety challenges with respect to the importance of operator's manuals.

For example, two of the top four hazards that construction workers face are classified as caught-in/between and struck-by incidents, both of which include incidents caused by the failure to properly operate heavy machinery (OSHA Directorate of Training and Education, 2011).

Why the Operator's Manual Matters

There are two primary reasons why most workers interact with the operator's manual: use and assembly. Many heavy machinery operators are trained on the job to use equipment and find themselves operating the equipment without adequately reading the manuals. The reason for this can be twofold. First, the training may have been insufficient, neglecting the operator's manual (e.g., OSHA, 2009). Second, heavy equipment is often rented, and may be dropped off without a manual (see Photo 1). While there are many similarities between different pieces of equipment, there can be significant differences. For example, a trackhoe and backhoe may have similar controls for the operation of the hoe, but the rest of

each machine is significantly different. Also, variations exist between manufacturers of the same equipment, and the same brand may include different control configurations for the same type of equipment. Despite these differences, heavy equipment operators may be expected to transition smoothly from one machine to another while working at a site (e.g., *Bennett v. Vernor*). Unless training and enforcement of safety procedures are effective, there is no guarantee that the safety devices on the equipment will be a part of the inspection checklist when operating a new machine (see OSHA, n.d.). The authors propose that item number one on an inspection checklist for heavy equipment should always be the operator's manual.

The operator's manual contains essential information for safe operation of equipment. Two sections of the operator's manual are critical for review: safety and operation instructions. Therefore, these two sections must be clear, concise and correct. Workers should always consult the operator's manual before operating machinery, follow the inspection checklist (with attention to safety systems) and identify any issues that are new relative to the worker's experience.

With regard to assembly, some pieces of heavy machinery are assembled by workers near the site where the equipment is to be used. In these cases, the operator's manual includes an assembly section or, more rarely, a separate assembly manual. For example, the operator's manual for a flatbed trailer will include hookup (assembly) instructions (e.g., PJ Trailers, 2005). Safety instructions for assembly often will be different from usage or operation safety instructions (e.g., Wisdom Industries, 2008). However, the same principles apply: it is critical that the sections or manuals are clear, concise and correct.

Layout of the Operator's Manual

As discussed in ANSI/ASSP Z490.1-2016, Criteria for Accepted Practices in Safety, Health and Environmental Training, training adults requires consistency and building on their own experiences. Consistency in operator's manuals

KEY

TAKEAWAYS

- Operator's manuals provide essential information for the safe operation of equipment; yet there are challenges in presenting this information clearly, concisely and correctly for an adult learner.
- The purpose of this article is to provide a guide for safety professionals as they inspect this important component of the equipment.
- Root-cause analyses in incident investigations should include evaluation of the content in an operator's manual.

helps adult learners efficiently find the information they need under the less-than-ideal circumstances of many work environments (e.g., noise, irregular lighting, multiemployer situations, worker exhaustion). For example, it is common that a machine develops a maintenance problem that requires replacement in the midst of a coordinated activity (e.g., *Bennett v. Vernor*). Finding the safety checklist and operation instructions as quickly as possible requires an operator to be familiar with the sections that individual needs to review.

Two general standards apply to a user-friendly operator's manual, depending on the manufacturer's preferences. The international standard ISO 20607:2019, Safety of Machinery—Instruction Handbook—General Drafting Principles, lays the foundation. Building on this are several more standards targeting specific industries and the presentation of material, such as engineering design graphics. The international standard that builds on ISO 20607 is ISO 3600:2015, Tractors, Machinery for Agriculture and Forestry, Powered Lawn and Garden Equipment—Operator's Manuals—Content and Format, which is discussed later in this section.

Let's focus on the safety-related content in ISO 20607, as discussed in the scope section: "This document specifies requirements for the machine manufacturer for preparation of the safety relevant parts of an instruction handbook for machinery." The following excerpts from the ISO 20607 standard highlight critical components in an operator's manual, followed by an example that failed to meet the standard, from the authors' experience in forensic investigation. The comparison and contrast between the standard excerpts and the examples illustrate that operator's manuals are sometimes published that do not meet these basic objectives.

Section 4.1: The purpose of the instruction handbook is to provide the user with such information that the machinery concerned can be effectively and safely used . . . also considering reasonably foreseeable misuse. (ISO, 2019)

Example: One manufacturer had a safety hardware mechanism that frequently went missing and concluded that an engineering solution was not possible (*Bennett v. Vernor*, 2016, Dennis Grizzle deposition, pp. 72-75). The same manufacturer provided an inspection checklist including this safety mechanism in earlier versions of the operator's manual (CNH America LLC, 2006, p. 295; *Bennett v. Vernor*, 2016, Bates No. CNH000831-001135; Elizabeth Jensen deposition, pp. 76-77); however, the safety mechanism was absent from the checklist in a later version (CNH America LLC, 2007, Chapter 10; *Bennett v. Vernor*, 2016, Bates No. CNH000571-00830). And the checklist itself was not provided in the version of the operator's manual in use at the time of a fatality (CNH America LLC, 2010; *Bennett v. Vernor*, 2016, Bates No. CNH000253-000570).

Section 4.4: The instruction handbook shall be: (a) comprehensible . . . (b) as simple and as brief as possible . . . (c) expressed in consistent terms and units. (ISO, 2019)

Example: One manufacturer's operator's manual 1. consisted of more than 300 pages (CNH America LLC, 2010) and 2. was unclear in its use of terminology, specifically "operation" being the

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same as "powered on" (*Bennett v. Vernor*, 2016, Elizabeth Jensen deposition, pp. 42-43). In the authors' opinion, these are significantly different terms for an operator, with the difference being between the equipment's control levers being engaged versus the engine running. Another manufacturer switched terms for components between the assembly directions section and the companion parts handbook with assembly figures (Landoll, 2015a; 2015b).

Section 4.8: Warnings, hazard and safety symbols shall be distinguishable from other content of the instruction handbook. (ISO, 2019)

Example: One manufacturer directed operators to keep a safety device installed until they operated that particular part of the equipment (CNH America LLC, 2010, pp. 147/6-25, 150/6-28). The importance of the safety device was de-emphasized and introduced without any safety symbols designating that the failure to use it properly could lead to severe injury or death (*Bennett v. Vernor*, 2016, ACS Report No. C334JD-Supp, p. 14).

Section 4.9: The instruction handbook should be structured in such a way that the information can be quickly located. . . . Instruction handbooks shall be presented in such a way that the reader can determine if they are complete. (ISO, 2019)

Example: The manufacturer with the de-emphasized safety device also did not include the device's proper use in the safety section, deferring it to the working section 150 pages later in the operator's manual (CNH America LLC, 2010).

Section 4.10.1: Based on the risk assessment and the risk reduction measures the manufacturer of the machine shall inform and warn the target group. (ISO, 2019)

Example: One manufacturer had no procedure in place for reporting or investigating safety incidents, preventing the manufacturer from identifying assemblers of its equipment to be at higher risk (*Rincon v. Landoll*, 2017, ACS Report No. F087RR, p. 7, Elizabeth Jensen deposition pp. 165-166).

Section 5.2.5.1: Machines that are not assembled or installed by the manufacturer . . . shall contain the following instructions, if relevant: (-) requirements and



Photo 1: Heavy equipment rental with no operator's manual. The manual should have been attached to the wire shown. The operator cannot safely operate the equipment until one is obtained. This machine had an important piece of safety hardware, an item called the swing lock pin, improperly placed by the rental company.

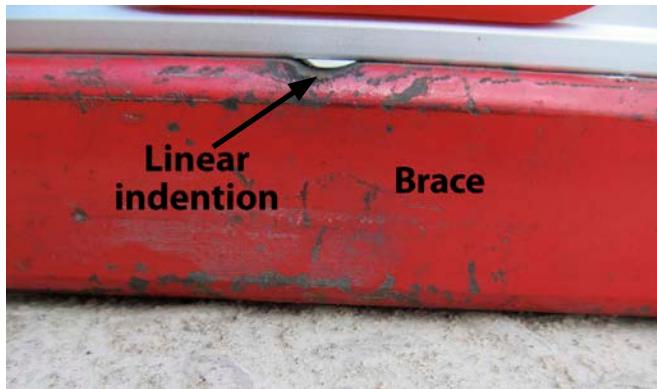


Photo 2: Redesigned safety hardware shows the damage it receives from 1 year of use. The previous design of this hardware failed from this usage, causing a fatality (as a root cause).

procedures for assembly and mounting (for example, temporary support or safeguarding . . .). (ISO, 2019)

Example: One manufacturer distributed equipment without testing its assembly directions first (*Rincon v. Landoll*, 2017, ACS Report No. F087RR, pp. 5-6, Elizabeth Jensen deposition pp. 146-147, 165-166).

Section 5.2.7: The instruction handbook shall include instructions regarding operating safety considerations, such as: (-) procedures for starting, control during operation, stopping. . . (ISO, 2019)

Example: One manufacturer had two different procedures for an operation (CNH America LLC, 2010, pp. 150/6-28, 152/6-30), and both had fundamental problems. The physical location of the operator was either not possible or awkwardly contorted, indicating that the procedures had not been tested and verified (*Bennett v. Vernor*, 2016, Elizabeth Jensen deposition, pp. 74-75).

The primary difference between ISO 20607 and ISO 3600 is in the presentation of information. ISO 20607 Section 5.1 lists the sections of an operator's manual that may be relevant; however, its guidance for the order of the sections is less restrictive. ISO 3600 Section 4.1 states, "NOTE: it is recommended that the order of information be as in the following clauses, but deviations may be made to suit particular machines and/or situations." Both standards recommend the safety section follow the opening material. ISO 3600 recommends following the safety section with "Operating Instructions," whereas ISO 20607 does not list "Operation" until the Section 7.

The authors propose that the operating instructions should follow the safety section as recommended in ISO 3600. Adult learners have a breadth of experience, and the majority of those who operate heavy machinery are already trained on other equipment. Most users will have familiarity with the various safety warnings and operations issues, such as how to safely navigate a road, and will not be involved in maintenance nor transportation of the equipment. We find that users' primary interest in reviewing the operator's manual is to safely operate those components of the machine that make it unique. In the authors' opinion, 1. any preceding material to the operations section of the manual becomes a delay in learning what makes the new equipment unique in the operator's experience; 2. any errors, omissions or unnecessary explanations in the text regarding the operation of the machine translates to a delay;

and 3. Operators are neither engineers nor safety professionals themselves; rather, they follow a goal-based strategy for using the equipment to accomplish an assigned task. The layout of warnings, figures and text should be focused on facilitating the operator's objectives.

Finally, in the authors' opinion, the safety sections of all operator's manuals should include a preoperation checklist. If one manufacturer provides or fails to provide a checklist, this piece of qualitative data could be used with other measures to estimate the overall safety of the equipment.

Summary of Operator's Manual Content Inspection

Safety professionals must be aware of the quality of information being provided by manufacturers. The preceding examples cover heavy equipment in agriculture and construction, ISO 3600:2015 and ISO 20607:2019(E). In discussing these standards, examples are provided of ways that manufacturers' operator's manuals can be insufficient. From the authors' experience, issues that safety professionals should inspect include:

1. Is the operator's manual present, current and complete?
2. Is the manual brief, containing a safety section an operation section immediately following (if appropriate)?
3. Is there an inspection checklist detailing the safety devices?
4. Can an operator follow the procedures without confusion in terminology or physical location while following the directions?

Incident Investigation

When an incident occurs, safety professionals will initiate an incident investigation and identify potential root causes of the incident. Note: "root cause" by definition does not include injured workers themselves. Root-cause analysis is the search for *other* contributing factors (OSHA, 2016). The operator's manual for any equipment that may have been involved is a significant document for understanding what training was needed and what safety procedures were enforced. However, it is rare to qualitatively measure how clear, concise and correct an operator's manual is. An incident investigation must include a review of the entire document, including the step-by-step instructions for the operator or assembler (e.g., OSHA, 2014). Errors in procedures can go undetected for years by administrators with the power to change the text (e.g., CNH America LLC, 2010). The authors find that workers and on-the-job trainers are the best source of information for identifying these errors based on deposition testimony and discovery materials.

The manufacturer has the primary role in determining that the operator's manual has failed to be clear, concise and correct. When an incident occurs, some manufacturers will have the dealerships report the incident. Regardless of whether the manufacturer has this specific procedure in place, a responsive organization will have a knowledgeable person or team responding to an injury or fatality report by collecting complete information about the incident (e.g., *Bennett v. Vernor*, 2016). Updating the operator's manual is a lower priority relative to engineering design considerations, since a design modification that can eliminate a hazard is best practice (Yates, 2015). However, every incident should be investigated with an examination of what the operator's manual states should or should not be done under the circumstances in which the incident occurred. The authors' opinion is that a responsible manufacturer will

1. include instructions to customers on how to report when its product was involved in an incident (or close-call/near-miss);
2. have a way to collect detailed information on the incident by

knowledgeable people; and 3. include its operator's manual in the analysis for every incident.

Operator's Manual Checks on the Manufacturer for Safety Professionals

Unfortunately, it is difficult for safety professionals recommending equipment purchases to identify manufacturers undertaking these steps when their company is selecting equipment to rent or purchase. The following tips are suggestions for identifying responsible manufacturers.

1. Observe vendors' on-the-job trainers when they discuss the operator's manual and its content with a new trainee. The trainer should be clear, concise and correct. In the authors' experience, shortcomings of the operator's manual become apparent during the training. For example, when the operation procedures in the manual are communicated, any issues with operating the equipment that are not in the manual would be covered.

2. When judging an equipment purchase, inquire whether the manufacturer hired an outside contractor to write the manual. The publishing company's client is not the operator of the equipment, who would value concise brevity, but rather is the manufacturer, who may value a large quantity of pages. For example, the 300-page operator's manual described in this article was generated under these circumstances (*Bennett v. Vernor*, 2016, Dennis Grizzle deposition, pp. 30-31). In comparison, the operator's manual for a similar piece of equipment published by another manufacturer is only 60 pages long and substantially more user-friendly (Deere, 2017).

3. When considering an equipment purchase, a buyer should ask the dealer how incident reporting is managed with the manufacturer. If the answers raise concerns, request more information from the manufacturer. The manufacturer may not be collecting the information in a coherent process and cannot answer. For example, one manufacturer directly copied unidentified standards to supplement its operator's manual (Wisdom Industries, 2008). In this general material was the direction that the owner/operator should report incidents to the manufacturer (p. 14). It was not until following a fatality (OSHA, 2014) that the manufacturer apparently learned that an important safety component in its equipment was prone to damage (Photo 2).

4. Check how new technologies have changed the machinery. If new equipment has an electronic interface, it is unlikely that all of the settings are discussed in the operator's manual. Also, the user may not be able to modify all of the settings, which requires a specialized technician to access them (e.g., Raymond, 2016). When equipment is purchased, be sure to have a manufacturer's technician walk you through all of this information.

Conclusion

This article is a guide for safety professionals to use when evaluating operator's manuals. In the context of heavy machinery, operator's manuals can be as important as on-the-job training. In discussing what exactly comprises clear and concise content, two standards are referenced, ISO 20607 and ISO 3600, to guide the reader in recognizing good operator's manuals. These references are compared to examples of improper, obfuscating material in operator's manuals to illustrate how to qualitatively measure the effectiveness of manuals.

Responsible manufacturers will have processes in place to collect information from an incident and determine how to

improve the operator's manual as well as the product itself, if necessary. Manufacturers should have customers register to receive updates to these essential documents. If the equipment was purchased on a secondary, used market, the manufacturer should still have customers register equipment. However, if that is not possible, then the safety professional should periodically contact the manufacturer to determine whether any new versions of the operator's manual exist. No operator's manual is ever the final version until the production line ends. **PSJ**

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