Replacement of safety windows on forest harvesting machines

– results of a Nordic survey

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Summary and conclusions

The safety windows of forest machines constitute a protective barrier shielding machine operators from the intrusion of objects into the cab. But it happens that screens fail, sometimes even in situations when they are expected to function. The causes and extent of this problem are not known.

A web-survey was constructed with support from the Swedish SLO-foundation. Aimed at forest machine operators in Sweden, Norway and Finland, data were collected on replacement of forest machines' safety windows, due to ageing, wear and tear or after damage through incidents. Just over a hundred responses were received. Half the cases concerned changes due to ageing and half replacements after near-accidents.

The results show that replacements affect virtually all machine manufacturers. Both harvesters and forwarders seem to be affected to the same extent. Replacements due to ageing and wear and tear occur mainly after about ten years, while replacements after breakdowns due to incidents also affect newer machines. The analyses has not clarified any previously unknown causal relationships or risk factors, but has provided a better basis for quantifying them.

For harvesters, it is primarily the front window that is damaged in the event of an incident. The work tasks that are particularly vulnerable are processing, when a tree is accidentally fed towards the cab, and felling especially if the risk of being hit by falling dead trees and tops is considered.

Also for forwarders, the front window is most prone to damage in the event of an incident, but side and rear windows are also exposed. The risk is greatest when loading, when logs are lost from the grapple. Terrain driving with an overfull load is also risky, as slippery timber can slide over the loading gate and hit the cab. Further, incidents are not uncommon during unloading and piling at the landing, especially as logs are dropped from the grapple.

To reduce the risk of incidents and accidents, a safe mode of working is the only solution:

- Follow the machine manufacturer's instructions for maintenance of the windows. Do not use unauthorized means, such as brake cleaning fluid and similar. This may damage the protective surface coating of the windowpane.
- Check the panes when cleaning. Watch for scratches and yellowing. Microcracks, e.g. at mounting points, show that the pane has deteriorated and should be replaced.

For forwarders

- Do not load over the gate. Keep in mind that the top logs can bounce over the gate, especially when driving downhill.
- Take extra care when lifting the grapple high. Icy or wet logs can easily slip from the grapple.
- Don't take larger bundles of lumber than what allows the grab shanks to meet.

For harvesters

- Avoid processing logs in the direction of the cab. If this is unavoidable, for example during thinning, a dead man's grip-function should be used for feeding.

- Pay special attention when felling and processing near standing dead trees. If you judge that they pose a great risk, fell them. They have conservation benefits also on the forest floor.
- Do not point the saw sword at the cab or at nearby machines when cutting.

Background

The safety windows of forest machines aim to protect the operator against objects penetrating the cab while allowing the visibility required for efficient and safe work. The windows are made of polycarbonate and meet the requirements of certification tests. Despite this, they sometimes break, also in situations where they are expected to last (Jönsson 2015). Protective panes also age, which manifests itself in the form of discoloration, scratches and microcracks. Then they are no longer adequate and should be changed.

This publication presents results from a survey on causes for replacement of protective windows of forest machines. In a collaborative effort Skogforsk, Skogkurs and Metsäteho, performed a survey among forest machine owners in Sweden, Norway, and Finland. Forestry in the three countries is very similar, which means that damage risks and ageing of the polycarbonate panes should follow the same patterns. The collaboration has resulted in a larger relevant data set. Hopefully this will give a better picture of what causes changes of safety windows and, perhaps even, whether certain machines, window types or work tasks are extra exposed.

The survey was posted online and the link to the survey consequently sent to major machine owners and contractor organizations in the three countries. We thank all respondents who have contributed data over why and how often safety windows of forest machines need to be replaced!

A total of 104 individual responses were received regarding the replacement of safety windows due to ageing, incidents or manufacturing defects. Of these, 101 could be used, while three answers were excluded due to incomplete data making interpretation impossible. Half of the answers concern Swedish machines, 40 percent Finnish and 10 percent of the answers are from Norway.

Good representation of machine types and manufacturers

The material includes 54 harvesters, 46 forwarders and one harwarder. Sixteen different brands are represented, but five manufacturers, John Deere, Komatsu, Rottne, Ponsse and Eco Log/Gremo together account for 94 % of the machines (Figure 1).

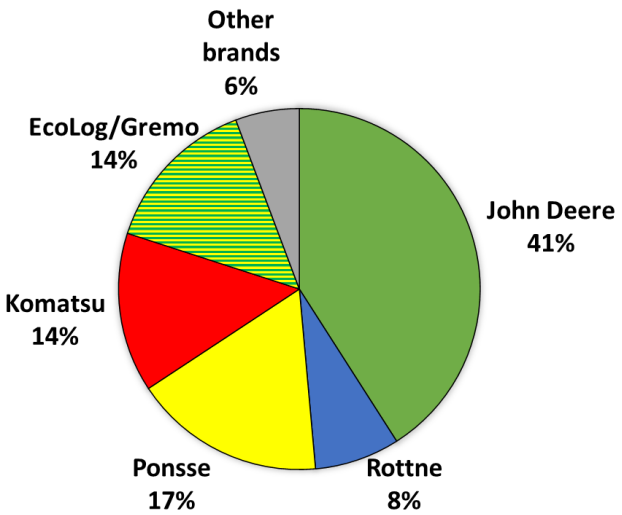

Figure 1. Five manufacturers represent 94 % of the window replacements reported in the survey.

Most machines reported in the survey are relatively new. Figure 2 show the distribution of machines by year of manufacture over replacements due to ageing (disposal) and post-incident replacement respectively. (The five oldest machines in the material, 1974–1999, were excluded). The figure shows that the slightly older machines (2001–2013) dominate in terms of replacements due to ageing, while

newer machines (2014–2021) dominate reports of replacement due to incidents. On average the machines with windows replaced after an incident were 5 years old, while the machines reporting window replacement after ageing were 10 years old.

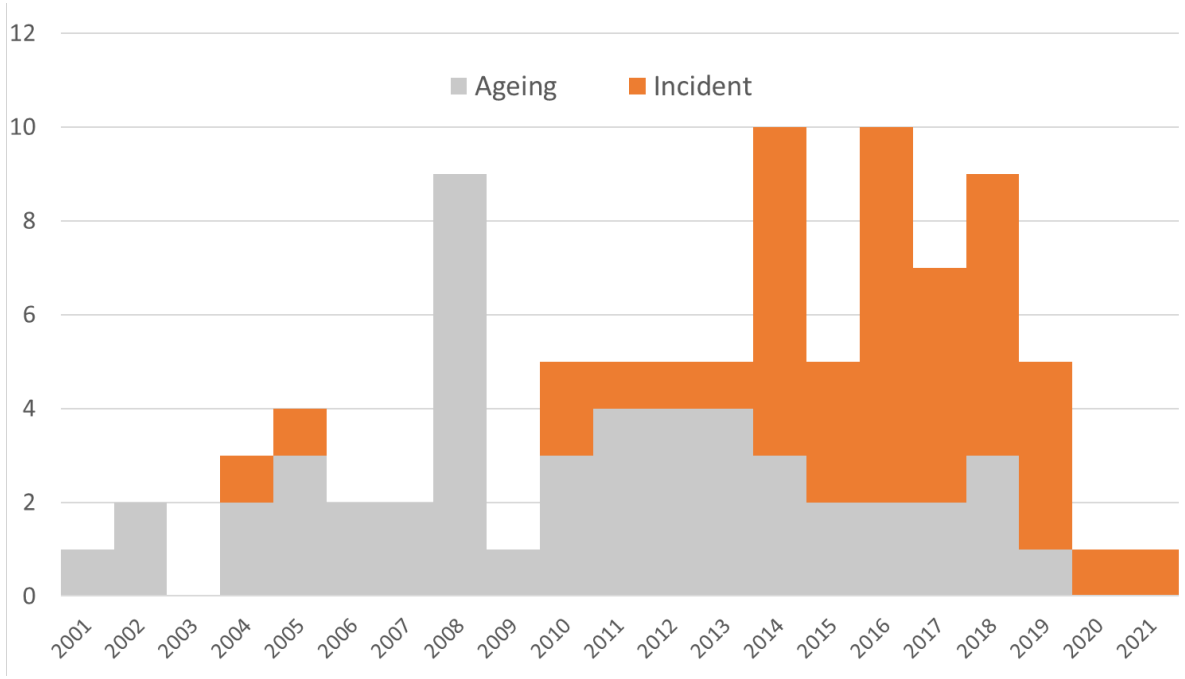

Figure 2. The machines are relatively new. Window replacements due to ageing are more common for machines >10 years while incidents predominate as the cause of replacements for machines <10 years. The five oldest machines in the material have been excluded from the graph above.

Replacing the safety panes due to ageing dominates in the material

In the study, we tried to distinguish between replacements after incidents ("near accident") and replacements due to slow deterioration, over time. Sixty percent of the reports concerned replacements due to ageing, i.e. gradually deteriorating properties such as discoloration or scratches. In 37 % of cases, the cause could not be concluded (Figure 3). Replacements due to ageing are about as common for harvesters (52 %) as for forwarders (48 %).

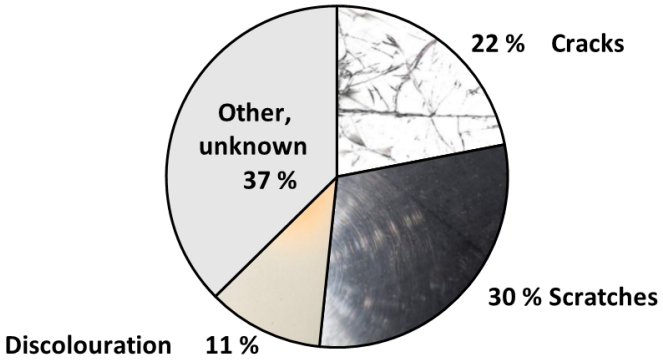

Figure 3. Causes of pane replacement after ageing. Microcracks and scratches form the basis for more than half of the cassations.

Replacing security windows after an incident that damaged the pane

As many as forty percent of the panes were replaced after an incident. An incident refers to a sudden event that did not cause personal injury but could have ended up as an accident. Incidents appear to affect the two types of machinery equally, possibly with a slight over-representation of harvesters (55 %) against forwarders (45 %).

Incidents causing damage to the safety windows of harvesters

In the survey, the driver was able to indicate the work task performed at the time of the incident (Figure 4). Processing is the riskiest element, accounting for more than half the reported incidents. The typical situation is that logs have been fed into the window. In 15 % of the incidents in connection with processing, a chain shot from the saw chain hit and damaged the window.

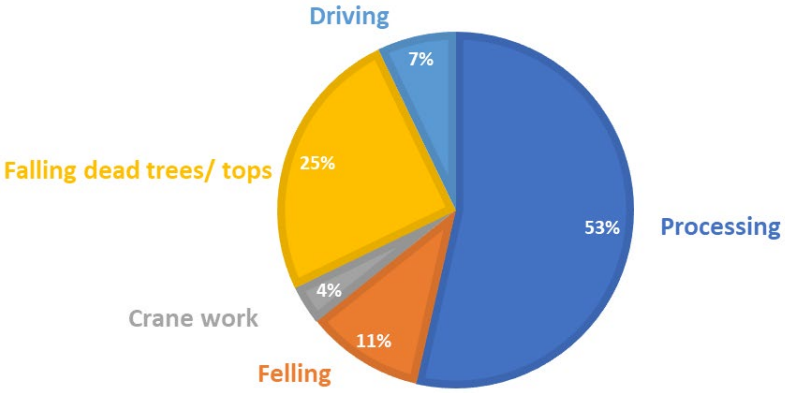

Figure 4. The distribution of incidents over different work tasks for harvesters.

Eleven per cent of the incidents occur during felling. Falling trees and tops are a category that is very strongly linked to the moment of felling. If incidents due to falling dead trees and tops (25 %) are added to the category of felling, they account for more than a third of the incidents. In one case, the window was hit by a chain shot from felling.

Incidents also occur during crane work, e.g. by accidentally hitting the cab with the logging head. Driving in the stand can also cause incidents, as when dead standing trees fall as the heavy machine passes and or when trees or branches come in tension and hit the windows.

For harvesters, the front window is by far the most vulnerable to incidents. In the dataset, almost 90% of incidents affected the front window (Figure 5).

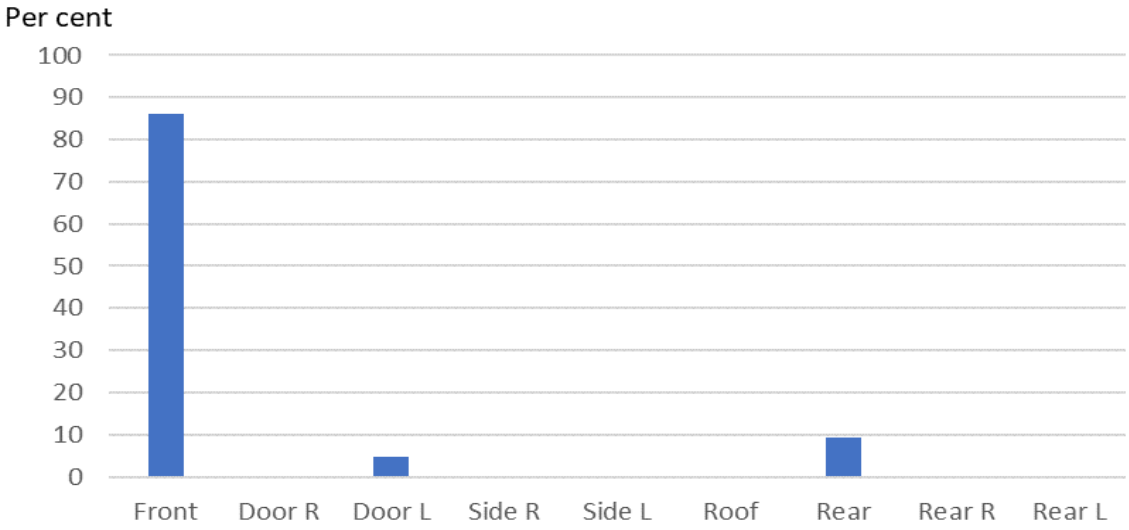

Figure 5. For harvesters, the front windowpane is most commonly damaged.

Incidents causing damage to the safety windows of forwarders

Loading is the riskiest work task and accounts for over half of the incidents reported for forwarders (Figure 6). The typical incident is that logs dropped from the grapple falls or bounces against the cab. Another situation is that small trees and branches are broken and hit the pane with high force.

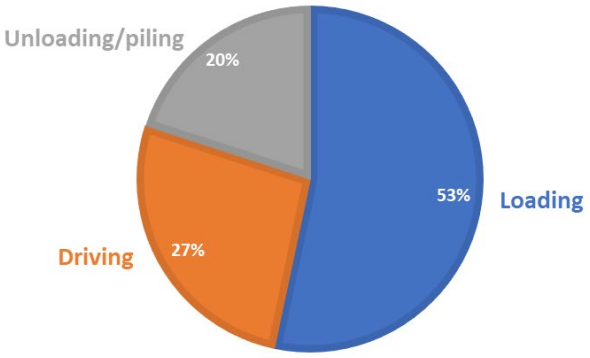

Figure 6. The distribution of incidents over different work tasks for forwarders.

Just over one quarter of incidents for forwarders occur while driving. The most common cause is that logs, slippery due to sap, rain or ice, slips over the loading gate and hits the rear window when driving downhill. About a fifth of the incidents occur during unloading when piling at the landing. The risks are similar to what was described for loading: timber is dropped out of the grapple.

Also for forwarders, it is the front window that is most commonly damaged, but rear and side windows seem more exposed to incidents than for harvesters (Figure 7).

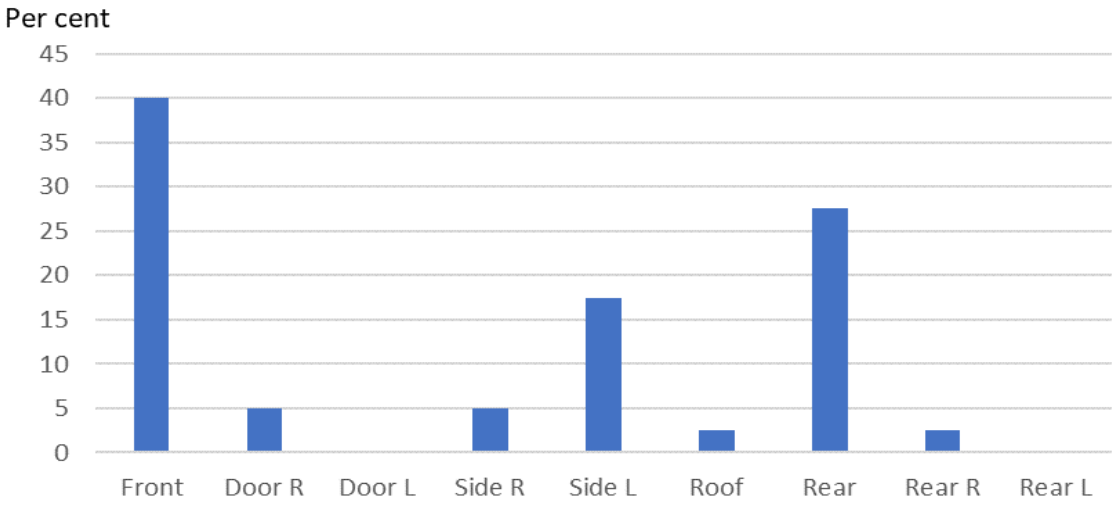

Figure 7. The front window is the most frequently damaged pane on forwarders, but incidents affecting other panes frequently occur.

Discussion

The survey allows us to quantify why safety windows of logging machines are replaced, both as an effect of ongoing maintenance or as an effect of incidents/near accidents. We also see in which situations an incident or accident is most likely to occur.

It can be concluded that the problem is not tied to any specific manufacturer or machine model. Most manufacturers and a large number of machine models are represented in the material. However, since the survey has been based on voluntary reporting, there is no control over the representativeness of the responses. The response rate has been sufficient to identify typical situations and to roughly quantify the relative frequency of various injuries. But the data set does not allow speculation about whether certain manufacturers, machine models or types of security panes are overrepresented. There is probably a significant number of unreported cases. There is also a risk

that the answers are partly derived from non-representative clusters of respondents, such as a larger contracting firm with a certain type of machine. This can affect the result. A controlled data acquisition ensuring representativeness of data is needed to provide a more reliable and complete picture of the causal relationships that lead to the failure of polycarbonate windows.

The material collected through the survey is too small for analysis of a number of interesting factors such as the age of the windows that have failed in incidents and whether cracks, discoloration or scratches have been noted before the incident. Manufacturers' statistics for the replacement of broken windows in the last 5 years with division into broken windows (incidents) and ageing would be a good start.

The protective ability of safety windows decreases over time. The material of the safety windows is polycarbonate, which over time is broken down by the sun's UV radiation. The molecular chains then become shorter, and the strength of the pane decreases. To protect the panes from UV, they are coated with a thin protective film, but the UV protection factor is not one hundred percent. If the pane is scratched or cleaned with inappropriate cleaning agents, the material is more exposed to UV radiation and the degradation is faster. Taking this into account, machine manufacturers should probably declare the expected useable life-time of security windows.

Skogforsk, in collaboration with Glafo (Lang, Jönsson and Englund 2016), tested the molecular weight of a single damaged pane. No degradation of the polycarbonate could be found, but it would be desirable for more panes to be tested. Samples from damaged panes should routinely be analyzed when the window is replaced.

Current strength testing is based on static loading of the pane, but during practical work impact stress is often characterized by dynamic forces. An orderly experiment to check the performance of the polycarbonate panes in situations more similar to actual work and environmental conditions would be welcome (for example, a heated cabin with sub-zero temperatures on the outside).

The design of the pane (flat or curved), the method of forming and the way of mounting the windows on the cab (glue, screw…) are of importance for the protective function of the pane. These parameters have not been thoroughly examined and reported. Much remains to be done.

Forest machine operators are advised to carry out the work in such a way that the risk of incidents is minimized, not only because of the above uncertainties. Advice to machine operators on how this can be done (Björheden 2020) is repeated in the beginning of this publication.

Learn more

The Interreg project ” Skogsjobb i gränslandet”, 2022. Information clip ”Safety in the cab” on Youtube: https://www.youtube.com/watch?v=S02wpgG6VIg&t=161s (Swedish/Norwegian)

Björheden, R., 2020. TSG informerar - Skogsmaskinens säkerhetsrutor (In Swedish) https://www.skogforsk.se/cd_20200917134109/contentassets/7eccf432a4da415a814dbb5ee4e4a267/tsg-rekommenderar---sakerhetsrutor-sis.pdf

Jönsson, P., 2015. Många möjliga orsaker till trasiga rutor. (In Swedish) https://www.skogforsk.se/kunskap/kunskapsbanken/2015/manga-mojliga-orsaker-till-trasiga-rutor/

Lang, M., Jönsson, P. & Englund, M., 2016. Varför spricker maskinrutorna? (In Swedish) https://www.skogforsk.se/kunskap/kunskapsbanken/2016/varfor-spricker-maskinrutorna/