REPORT

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THE IMPACT OF WASHING, PETROL AND OIL ON PROTECTIVE LEGWEAR

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Summary

The impact of petrol, oil and washing on the cut-resistance of chaps was investigated. After exposure to varying levels of petrol, oil and washing, the chaps were cut tested (along with a control group). The control, washing and petrol groups all passed the New Zealand Standards test - NZS 5840: 1988, Amendment 1 (NZS 5840). However, all chaps exposed to even the smallest quantity of oil (0.5L) provided almost no resistance to the chainsaw, failing the New Zealand Standards test. Further research needs to be conducted to investigate whether smaller quantities of oil, the type of washing (cold, warm, or hot), and type of washing powder have any impact on chap performance. Further research also needs to be carried out to determine whether it is possible to restore the protective properties of oil exposed legwear by removing the oil in some way (e.g. machine washing or washing with petrol).

Recommendations

- Legwear should be replaced every six months or after a total of 0.5L (one chainsaw tank) of oil has been spilt on the legwear.
- Forest workers should regularly check and tighten the oil cap on the chainsaw to avoid it coming off and large quantities of oil being spilt on their protective legwear.
- Manufacturers of legwear should develop an oil proof outer to prevent oil ruining the protective properties of the legwear. Manufacturers must ensure that the addition of an oil proof outer does not increase the heat retention of the legwear.

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WARNING

Protective legwear is cut-resistant, not cut proof! Protective legwear is designed to stop a chainsaw with a chain speed of 20m/sec. Some chainsaws are capable of producing a chain speed of 34m/sec.

Introduction

A small number of laboratory-based (Arteau, Arcand & Turcot, 1995; Putnam, Jackson & Davis, 1982) and field studies (Sullman, 1996) have investigated the factors which impact on the cut-resistance of protective legwear. Arteau et al. (1995) found factors such as the sharpness of the chainsaw chain, chain type, angle of cutters, condition of the clutch, petrol and oil mixture and the chainsaw's stability significantly affected the chain speed that the legwear could resist.

Putnam et al. (1982) found that washing and drying protective pads resulted in a small decrease in the maximum chain speed the pads were able to resist. According to Milling (1996), Swedish research also found that washing detergent reduced the legwear's level of performance. Putnam et al. (1982) also found that petrol and oil had no impact on the maximum chain speed the protective pads could pass.

However, Putnam et al. (1982) used very small sample sizes (1-4 pads). The New Zealand Standard (NZS 5840) requires a much higher level of protection than that found in any of the pads Putnam, et al. (1982) tested (20 m/sec. versus 14.33 m/sec.) and the protective pad design was different from those manufactured in New Zealand. The impact that washing, oil and petrol have on the cut-resistant properties will vary according to the properties of the materials that make up the protective pads. Therefore, it is very likely that results from overseas studies would not be directly applicable to protective legwear in New Zealand.

Recent New Zealand research (Sullman, 1996) found that after six months' use by full time loggers, the level of cut protection offered by the protective legwear had deteriorated to a level below that required by the New Zealand Standard. That study highlighted the need for further research to identify which factors contributed to the deterioration of the protective legwear. Although the study identified a number of factors as being important, given the research methodology it was not possible to identify which factor(s) were responsible for the legwear's deterioration. Therefore, Sullman (1996) specifically stated the need to investigate the impact of washing, petrol and oil on chap performance. The impacts of these factors on the legwear's performance were investigated in this study.

Methodology

Eighteen pairs of "S-marked" chaps, which had been manufactured in accordance with the New Zealand Standard (NZS 5840) were purchased directly from the manufacturer. The chaps all came from the same batch to prevent any possible variations in the quality.

Group Label	Number of Legs Tested	Treatment	x	Number of Treatments	=	Total quantity of exposure
Control	6	Nil		Nil		Nil
Wash 2	6	1 wash		2		2 washes
Wash 5	6	1 wash		5		5 washes
Wash 10	6	1 wash		10		10 washes
Oil 2	6	0.25L of oil		2		0.50L of oil
Oil 5	6	0.25L of oil		5		1.25L of oil
Oil 10	6	0.25L of oil		10		2.50L of oil
Petrol 2	6	0.85L of petrol		2		1.70L of petrol
Petrol 5	6	0.85L of petrol		5		4.25L of petrol
Petrol 10	6	0.85L of petrol		10		8.50L of petrol

Table 1- Experimental design

Control

Six chap legs were not washed and were not exposed to oil or petrol, but were stored in a box for the duration of the experiment to prevent any accidental contamination.

Washing

The chaps were washed by the same methods used by the loggers in the previous LIRO research (Sullman, 1996). The chaps were machine washed in a Fisher and Paykel OW51 Smart Drive on "normal cycle", with a wash temperature of "cold". In accordance with Cold Power™ recommendations for "Heavily Soiled" clothing, two cups (400ml) of Cold Power™ washing powder were used for each wash. This type of washing was not necessarily the manufacturer's recommendations, but was used because this is how chaps are washed by loggers in reality (Sullman, 1996).

Petrol

The petrol used in this case was 91 octane petrol, with a 30:1 mix of petrol to two stroke oil. Petrol exposure was measured in terms of chainsaw petrol tanks to make the volumes easier for chainsaw operators to visualise. A Husqvarna 288XP, which has a petrol tank size of 0.85L, was chosen as the "typical" size for chainsaw operators working in clearfell. Each tank (0.85L) of petrol was spread evenly over each chap leg and left to be absorbed by the legwear.

Oil

As with petrol, exposure to chainsaw bar lubrication oil was measured in terms of Husqvarna 288XP oil tanks (0.5L). However, as the protective legwear's ability to soak up the oil was not as good as expected, the application rate was half a tank. Each half tank (0.25L) of oil was spread evenly over each chap leg and left to be absorbed by the legwear.

Storage of Chaps for Drying

After each treatment (wash, exposure to 0.25L of oil, exposure to 0.85L of petrol) the chaps were dried. As with Luston, Mañasek and Samuhelovà, (1979), the chaps were dried at room temperature for at least 24 hours after each wash or exposure to petrol or oil. The different treatment groups (oil, petrol and washing) were stored separately to avoid contamination. The chaps were laid flat to dry on the shelves of a storeroom. Storage and treatment of the chaps was undertaken away from sunlight, in case sunlight exposure affected the chaps performance.

To allow an estimation of the amount of extra material (oil, petrol and washing powder) retained by the chap, the chaps were weighed before the experiment began and prior to cut-testing.

Test Procedure: NZS 5840

The chaps were cut tested according to the New Zealand Standard NZS 5840 using the method described by Sullman (1996).

Results and Discussion

Table 2 contains the information on mean chap weights, the number and percentage of layers cut through and whether the chaps passed or failed.

Group Label	Mean weight Before (grams)	Mean weight After (grams)	Mean number of layers cut through (out of 6)	Percent layers cut through (mean)	Pass/Fail
Control	952.6	952.6	4.2±0.7	70%	Pass
Wash 2	982.8	982.8	5.5±0.5	92%	Pass
Wash 5	967.7	997.9	5.0±0.6	83%	Pass
Wash 10	967.7	997.9	5.3±0.5	88%	Pass
Petrol 2	952.6	1088.6	4.5±0.5	75%	Pass
Petrol 5	997.9	1134.0	4.2±0.4	70%	Pass
Petrol 10	952.6	1118.9	5.0±0.6	83%	Pass
Oil 2	**967.7**	**1814.7**	**6.0±0.0**	**100%**	**Fail**
Oil 5	**997.9**	**2767.0**	**6.0±0.0**	**100%**	**Fail**
Oil 10	**952.6**	**2812.3**	**6.0±0.0**	**100%**	**Fail**

Table 2 - Results of exposure and testing

As would be expected, the weight of the control group did not change at all. The chaps that were washed twice did not increase n weight, while those washed five and ten times increased slightly. This slight increase could be either residual dampness or the retention of washing powder residue. The chaps exposed to petrol all increased in weight slightly. This increase must be due to the retention of residue from exposure to the petrol. All chaps that were exposed to oil increased weight dramatically, indicating that the oil soaked into, and accumulated inside, the chap legs.

Figure 1 graphically illustrates the performance of the chaps, in terms of the mean number of layers that were cut through for each group of six chap legs, after cut testing. In the control group, on average, the cut test resulted in 70% of the six layers being cut through. After exposure to petrol, on average 76% (range 70-83%) of the layers were cut through. Surprisingly, the mean number of layers cut through did not increase linearly with an increase in exposure to the petrol.

After the chaps had been washed, on average 88% (range 83-92%) of the layers were cut through. Again, the mean number of layers cut did not increase linearly with an increase in the number of washes. There are two possible reasons for the lack of a linear trend for both petrol and washing. The first is a small variation in the quality of the chaps and the second is a small variation in the quality of the testing (factors outlined by Arteau et al., 1995).

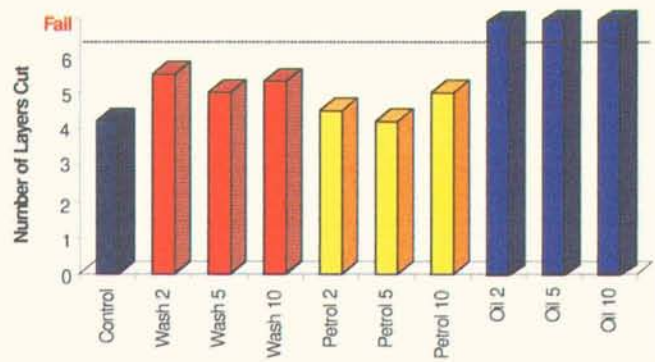

Figure 1 - Chap performance

Only one of the six legs in each group needs to fail for that group to fail the New Zealand Standards test. However, in all three oil exposed groups, all six chap legs failed. In fact, the chainsaw cut through all six layers of the protective material so easily that it damaged the test rig. Since chaps exposed to even the smallest quantity of oil (0.5L) failed, further research is needed to find out whether exposure to smaller quantities of oil causes chap failure.

According to the legwear manufacturers, oil exposure caused failure of the legwear by accumulating on the internal fibres, thereby increasing the internal friction between the strands. When the strands are touched by the chainsaw, the internal friction causes the strands to be cut through, rather than being pulled out and clogging the chainsaw as they were designed to. Therefore,

manufacturers should develop an oil proof outer to prevent the oil being absorbed into the protective material. However, the oil proof outer must not increase the heat retention of the legwear, since thermal comfort has been identified as the most important factor affecting wearer acceptance of protective clothing (Batel and Hinz, 1988).

On average the number of layers cut through after exposure to petrol (76%) were similar to the control (70%). However, after washing, on average the number of layers cut through (88%) was clearly greater than the control group (70%). According to legwear manufacturers, washing causes the layers of protective materials to tangle slightly, resulting in a small increase in the internal friction between the strands. This slight increase resulted in a greater number of layers being cut through than the control and petrol exposed chaps, but not as much as those exposed to oil.

Sullman (1996) notes that the impact of petrol, oil, washing powder on the protective legwear will vary according to the properties of the materials that make up the legwear's protective pad. Therefore, further research is needed to find out whether petrol (very minor impact), washing (minor impact) and oil (caused failure) affects other brands of chaps in the same manner.

Conclusions

- The control, those exposed to washing and petrol all passed the New Zealand Standards test.
- Chaps exposed to even the smallest quantity of oil (0.5L) comprehensively failed.
- Chainsaw operators should replace chaps which have been exposed to 0.5L of oil, as they provide almost no protection against a chainsaw.
- Further research is needed into whether the chaps would pass the New Zealand Standards test after being exposed to a smaller quantity of oil.
- Further research is also needed to investigate whether oil exposed chaps can be treated in some way (e.g. hot washed or washed in petrol) to remove the oil and restore the protection offered by the legwear.
- Another factor in need of further investigation is whether different types of washing and washing powder have any impact upon the chap's ability to pass the New Zealand Standards test.

Acknowledgment

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