The Effect of Protective Glove Exposure to Industrial Contaminants on Their Resistance to Mechanical Risks

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In several industrial environments, mechanical risks are often combined with various contaminants such as oils and greases, which may reduce the performance of protective gloves against mechanical hazards. However, glove properties are characterized on new and clean specimens, and little is known about their residual resistance once contaminated and over time. In this study, a series of protective gloves used in metalworking companies and garages were exposed to relevant oils and greases. Used gloves were also obtained from a food processing center and a garage. Their residual resistance to mechanical risks (cutting, puncture and tearing) was evaluated using standard test methods. Results revealed in some instances a large decrease in resistance to mechanical risks. Since a corresponding change in the material aspect may not always be easily observable, this may lead to serious safety breaches. These findings demonstrate the need to further the research in this domain.

protective gloves   industrial contaminants   mechanical risks

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1. INTRODUCTION

Hand injuries account for almost 20% of the accidents compensated for by the Commission de la santé et de la sécurité du travail du Québec (Quebec Occupational Health and Safety Commission) [1]. They even reach 30% in industrial sectors like metalworking and food processing. More than half of these hand injuries are cutting- and puncture-type lacerations. Designed to guard the hand against various types of hazards, protective gloves have demonstrated their efficiency in reducing the occurrence and the severity of hand injuries, especially lacerations and punctures for which the decrease in risk can reach 60–70% [2, 3]. As a tool for helping select the

optimal protection, standard test methods have been developed to quantify the level of resistance offered by gloves against various categories of aggressors [4]. Those relative to mechanical risks deal with cutting by slicing, puncture, tearing and abrasion [5].

However, while properties of protective gloves are measured on specimens just off the production line, workplace environments often involve the presence of industrial contaminants, in particular oils and greases, in addition to mechanical hazards. This situation prevails, e.g., in the metalworking sector [6], in automotive workshops [7] and in the food processing industry [8]. Exposure to these oils and greases may induce a reduction in the resistance of glove materials to mechanical risks, as it has been shown for neoprene cut resistance after application of a cutting fluid [9]. In general, mechanical properties of elastomers, in particular hardness, tensile strength and elongation at break, are affected by contact with oils and greases [10, 11, 12, 13, 14]. The net process involves two competing phenomena [12, 15]: while soluble species, e.g., plasticizers, are extracted from the polymer matrix, oils and grease components may diffuse into it. As a result, large changes in mechanical behavior may occur even at a low swelling ratio [10]. In addition, the effect of oils and greases on polymer properties is generally not associated with a modification in surface coloration [16, 17]. It must be noted that this difficulty of detection of a protection level degradation may induce a false feeling of safety for the user.

It has been observed that the extent and even the direction (increase or decrease) of the property change are highly dependent of the polymer material and the contaminant composition among others. For example, nitrile rubber displays a stronger resistance to hydrocarbon-based oils thanks to its polar nature [14, 18, 19]. In addition, oils and greases can have different levels of paraffinic or naphthenic hydrocarbon content, which may influence their miscibility in a given polymer [12]. Moreover, the numerous additives which are included in oil and grease formulations to improve their performance, e.g., antioxidants,

corrosion inhibitors and antiwear agents, may also have an effect on the degree of contaminant-polymer interaction [14].

The objective of the paper is to evaluate the severity of the effect of exposure of protective gloves to industrial contaminants on their resistance to mechanical risks. This subject has been largely neglected in the scientific and technical literature. More precisely, this paper reports on preliminary measurements performed both on laboratory contaminated samples and on used gloves (retired). Tested properties include resistance to cutting, puncture and tearing. The study focused on three occupational sectors where mechanical risks and oil and grease-type contaminants often coexist: metalworking, automotive mechanics and food processing.

2. EXPERIMENTAL

2.1. Gloves and Contaminants

A list of protective gloves and their corresponding contaminants was selected in collaboration with representatives from the metalworking, auto-mechanics and food processing sectors. They are listed in Table 1 along with glove constitutive materials and the type of applied treatment (laboratory contamination/retired gloves). It must be noted that, even if they do not provide any protection against mechanical hazards, disposable nitrile gloves have been included in the study since they are used in several industrial environments involving oil and grease contaminants, e.g., in the food processing sector to prevent direct contact between meat and cotton undergloves. Table 2 gives the available information in terms of formulation for the oils and greases used in the laboratory contamination treatments.

2.2. Laboratory Contamination Treatments

A laboratory procedure was designed to allow studying in a controlled manner the contact of protective gloves with contaminants. Two typical contamination periods were selected: 1 and 8 h. Longer contamination times were also used for disposable nitrile gloves.

TABLE 1. List of Tested Gloves With Constitutive Materials and Treatment Conditions (Laboratory Contamination and Retired Specimens)

Glove	Glove Material	Contaminant/Service Workplace
G1	nitrile rubber coating over a cut and sewn cotton liner	hydraulic oil cutting fluid
G2	nitrile rubber palm coating on nylon liner	cutting spray
G3	polyurethane (PU) palm coating on Dyneema® liner	metalworking lubricant
G4	unsupported nitrile rubber	retired from a food processing center
G5	disposable nitrile rubber	two-cycle motor oil automotive grease NLGI No. 2
G6	foam nitrile rubber palm coating on Kevlar® liner	5W-20 motor oil wheel bearing grease NLGI No. 2
G7	nitrile rubber palm coating on nylon liner	retired from a garage
G8	Clarino™ synthetic leather for palm and spandex back	5W-20 motor oil wheel bearing grease NLGI No. 2 retired from a garage

TABLE 2. Composition of the Industrial Contaminants

Contaminant	Listed Components
5W-20 motor oil	severely refined base oil
Automotive grease NLGI No. 2	severely refined petroleum basestocks lithium 1,2-hydroxystearate homopolymer ethene alkyl sulfides and other additives
Cutting fluid	severely hydrotreated naphtenic petroleum distilates monoethanolamine monoisopropanolamine alkoxylated linear alcohols sodium alkylbenzene sulfonate synthetic sodium sulfonate
Cutting spray	secret ingredient (65%) propane (25%) n-butane (10%)
Hydraulic oil	hydrotreated used lubricating oils (petroleum) hydrotreated lubricating oils (petroleum, c>25, bright stock basis) solvent-deparaffined residual oils (petroleum) solvent-refined residual oils (petroleum) mineral oil containing additive mineral oil zinc dialkylated dithiophosphates
Metalworking lubricant	triethanolamine oleic acid linoleic acid ether phosphate
Two-cycle motor oil	hydrotreated heavy paraffinic distilates kerosene petroleum, solvent-refined residual oils petroleum hydrocarbons
Wheel bearing grease NLGI No. 2	solvent-refined heavy paraffinic petroleum distillates solvent-refined residual oils (petroleum) molybdenum disulfide

The application of contaminants on glove specimens was performed while ensuring that contact only took place from the outside surface of the glove. In the case of liquid contaminants, the glove was delicately placed over a thin film of contaminant contained in a pan (Figure 1a). More viscous products like grease and foam were directly applied on the glove surface using a foam brush or a spray (Figure 1b).
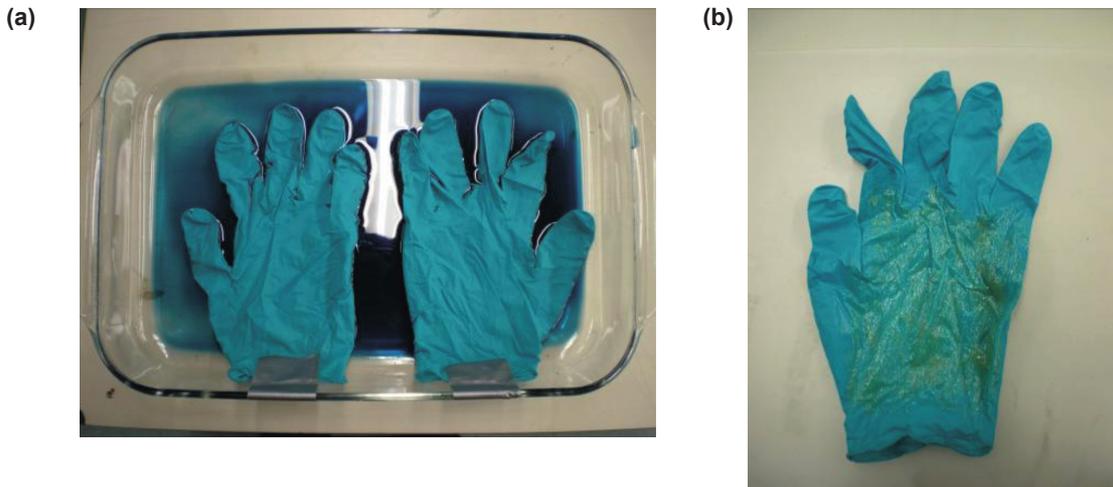
(a)

(b)

Figure 1. Contamination treatment setup for (a) liquid and (b) viscous contaminants.

Once the contamination period elapsed, the glove surface was delicately wiped to remove any excess contaminant. Sample shapes corresponding to the various measurements to be performed (see sections 2.4.–2.7.) were then cut out in the palm section. Tests were performed right away.

2.3. Use Conditions for Retired Gloves

Used specimens corresponding to three glove models (G4, G7, G8 in Table 1) were obtained from a truck workshop and a meat processing center. They were measured as received, i.e., without any cleaning performed. It must be noted that no information was available about the service history of individual glove specimens which were randomly distributed between the different tests performed.

Unsupported nitrile rubber gloves (G4) are worn at slaughtering, boning and cutting workstations. The gloves are in contact with animal fat, bones and muscles. They are cleaned by the workers themselves every worked day. They are washed in a 2–4% chlorinated alkaline soap solution, then hand-wringed and hung on a hook in a fan-equipped drying room. According to the manufacturer, these gloves are appropriate for food processing operations.

Two types of retired gloves were provided by a truck workshop. Nitrile rubber palm coated nylon liner gloves (G7) are used for lubrication operations and handling soiled pieces. Synthetic leather/spandex gloves (G8) are worn for heavier work like lifting metal parts. Both types of gloves are recommended for automotive mechanics by the manufacturer. They are exposed to several industrial contaminants, automotive oils and greases among others. These gloves are sent to an industrial cleaner along with the other work clothing. The cleaning treatment uses an organic solvent (Varsol) for degreasing. Both types of gloves are generally replaced after ~6 months.

2.4. Method for Measuring the Resistance to Cutting

Cut resistance was measured according to the ASTM F 1790-05 standard method using a tomodynamometer TDM-100 (RGI Industrial Products, Canada) [20]. The method is based on the determination of the force necessary for a razor blade to cut through the sample thickness after a 20-mm sliding displacement at a constant rate of 150 mm/min (Figure 2a). Sample cut-through is detected by electrical contact. A minimum of five replicates are performed for three different values of the vertical force applied on the blade, these 15 measurements being distributed on three glove specimens. Blades are replaced after each test. Blade lots are validated using the reference material specified in the ASTM standard, neoprene, which also provides the sharpness correction factor.
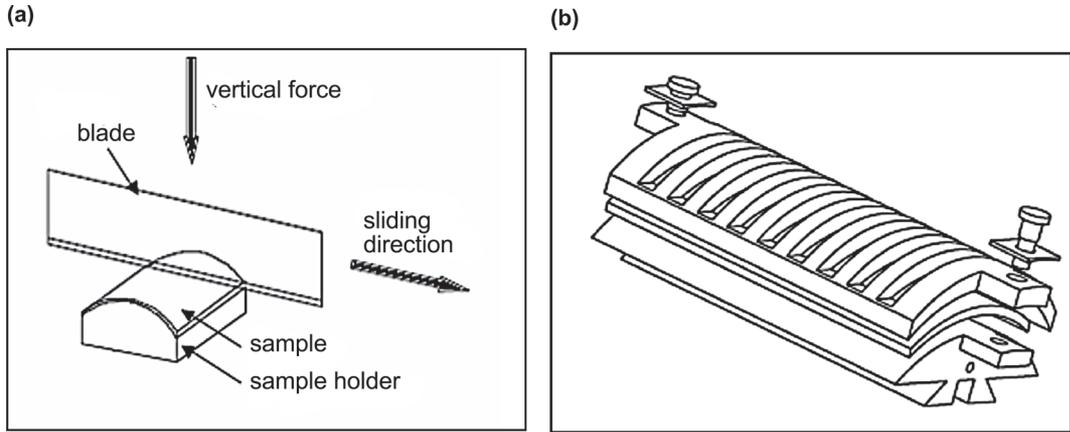
Figure 2. (a) Principle of the TDM-100 cutting test and (b) schematic representation of the sample securing clamp. *Notes.* TDM-100—tomodynamometer TDM-100 from RGI Industrial Products, Canada.

Samples were cut in the palm section of the gloves. They were attached to the hemicylindrical sample holder using double-sided adhesive tape. In the case of multilayered gloves and for those displaying adhesion difficulties, a clamp was specially designed [21] and used (Figure 2b). Its 0.2-mm wide grooves allowed the blade to slide through while maintaining the glove sample in position. A gentle pressure was applied to the clamp to secure the sample without crushing it.

The force corresponding to a 20-mm cutting distance, defined as cut resistance, was computed by fitting and interpolating the curve created by combining the cutting distance versus applied force data. Additional measurements were carried out if the fitting curve determination coefficient (R^2) was lower than .5 or if the calculated mean of a series of five verification measurements performed at the 20-mm cutting distance force was under 18 or over 22 mm as prescribed by Standard No. ISO 13997:1999 on cut resistance of protective clothing [22].

2.5. Method for Measuring the Resistance to Puncture

Puncture tests were performed according to the ASTM F 1342-05 standard test method [23]. Puncture resistance is defined as the required force to penetrate through a membrane sample with a standard probe. A schematic representation of the set-up is provided in Figure 3a. It includes two steel plates securing the sample, each one with a 10-mm diameter centered hole. The edge
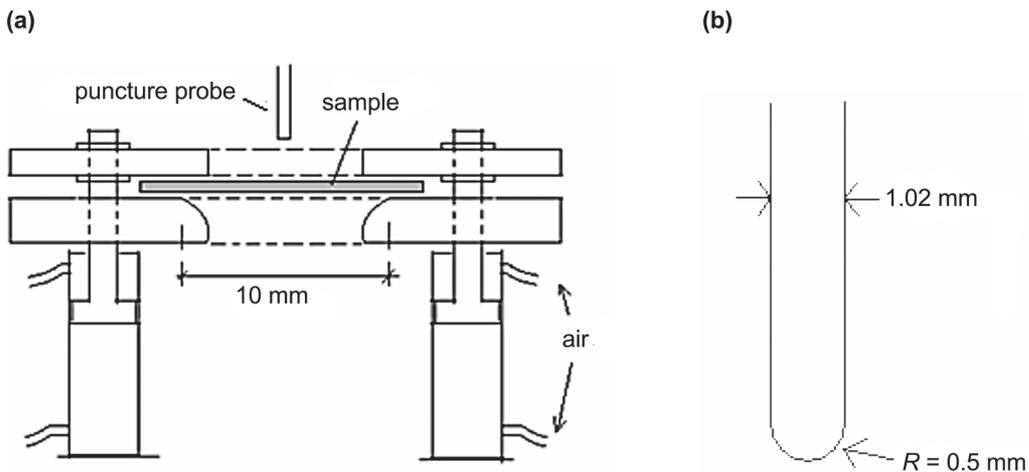

Figure 3. Schematic representation of (a) the puncture set-up and (b) type B puncture probe.

of the hole in the lower plate is rounded to avoid stress concentration. The set-up was positioned in a mechanical test frame with a 50-lb (222-N) compression load cell to which the puncture probe was affixed. The type B standard probe, a 1.02-mm diameter cylinder with a hemispherical tip (Figure 3b), was preferred because it has been shown to provide the best data reproducibility [24].

Samples were cut in the glove palm section of the gloves. The standard test method displacement rate of 500 mm/min was used for all samples except for the disposable nitrile rubber gloves for which it was 12.5 mm/min. This difference in probe displacement rate had no incidence on the data analysis since only relative resistance values (i.e., contaminated versus noncontaminated) were compared. Force and probe displacement data were recorded for each test, allowing the determination of the maximum force corresponding to the puncture resistance. For each glove model and each condition, 12 replicates were measured, equally distributed on four glove specimens and situated at a minimum distance of 25 mm from one another and from the sample edges. Mean and standard deviation values were computed from the results provided by these 12 replicates.

2.6. Method for Measuring the Resistance to Tearing

Glove tearing resistance was measured according to the EN 388:2003 standard test method [5]. Trouser-type samples were made from 100 × 50 mm strips with a 50-mm long longitudinal incision on one side (Figure 4a).

The two legs of the trouser-shaped sample were secured in the grips of a mechanical test frame (Figure 4b) and pulled apart at a constant rate of 100 mm/min. Force-displacement data were continuously recorded, making the determination of the maximum value of the force possible.

Four samples were measured for each glove model and each condition. These four samples were cut in the palm section of four different glove specimens, two longitudinally and two transversally. Resistance to tearing was provided by the lowest value of the maximum forces corresponding to these four samples.

2.7. Additional Characterizations

Tensile tests and measurements of weight change were performed on disposable nitrile gloves subjected to laboratory contamination to get more information on the mechanisms involved as a result of exposure to oil and grease for this homogeneous material.

Tensile tests were carried out according to the ASTM D 412-98 standard test method relative to vulcanized rubber and thermoplastic elastomers [25]. Dumbbell-shaped samples (matrix D) were cut in the palm section of uncontaminated and contaminated gloves. The two extremities of the test samples were secured in the grips of a mechanical test frame and pulled apart at a constant speed of 500 mm/min. Values of Young modulus corresponding to an elongation of 100% and of elongation at break were computed. Four replicates were produced for each condition.

For the weight change measurements, dumbbell-shaped samples (matrix D, ASTM D 412-98 test method [25]) were cut in the palm
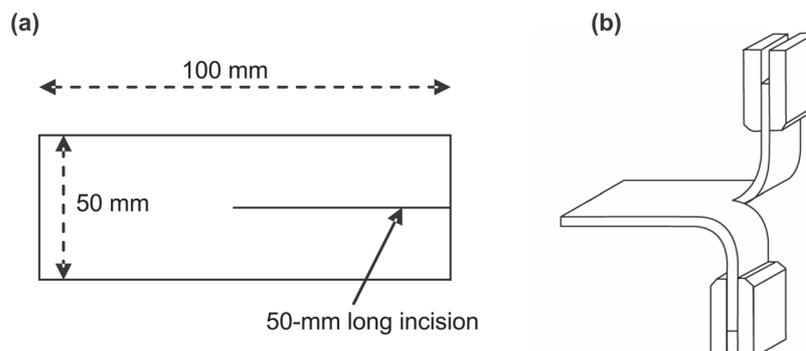

Figure 4. (a) Trouser-type sample dimensions and (b) sample configuration during tearing tests.

section of untreated glove specimens using a die and totally immersed in the contaminant during selected exposition times. The sample surface was carefully wiped before weighting was carried out with a precision balance. Three replicates were produced for each condition.

3. RESULTS

3.1. Laboratory Contamination of Disposable Nitrile Rubber Gloves

Disposable nitrile rubber gloves (G5 in Table 1) were subjected to laboratory contamination and exposed to two-cycle motor oil and automotive grease (see Table 2 for specifications) for up to 24 h. Measurements performed included puncture resistance assessment as well as weight change measurement and tensile tests. Cutting and tearing resistance results are not reported since, for these very thin nitrile rubber gloves, the force corresponding to unexposed specimens is already situated at the lower limit of the measurement techniques.

Figure 5 displays the variation of the exposed sample weight change ($(m - m_0)/m_0$) as a function of the immersion time in motor oil and grease

(m and m_0 are respectively the weight of the exposed and the unexposed samples). A minor weight gain is observed with oil and a relatively small increase in weight with grease. The order of magnitude of the observed weight change is in agreement with what has been reported in the literature [15]. This may indicate some fluid penetration into the disposable nitrile rubber glove samples.

Figures 6–7 display the results of the tensile tests respectively in terms of Young modulus corresponding to an elongation of 100% and of elongation at break as a function of the exposure time. A decrease in modulus leading to a plateau can be observed for both contaminants (Figure 6) while the elongation at break displays an increase also followed by a plateau (Figure 7). Such a reduction in stiffness and increase in elongation at break could be explained by the penetration of oil and grease components into the material (see Figure 5), which act as plasticizers in the polymer network [12, 26]. The presence of the plateau in modulus and elongation at break could be linked to the very small thickness of the gloves and indicate that a maximum in swelling has been reached.
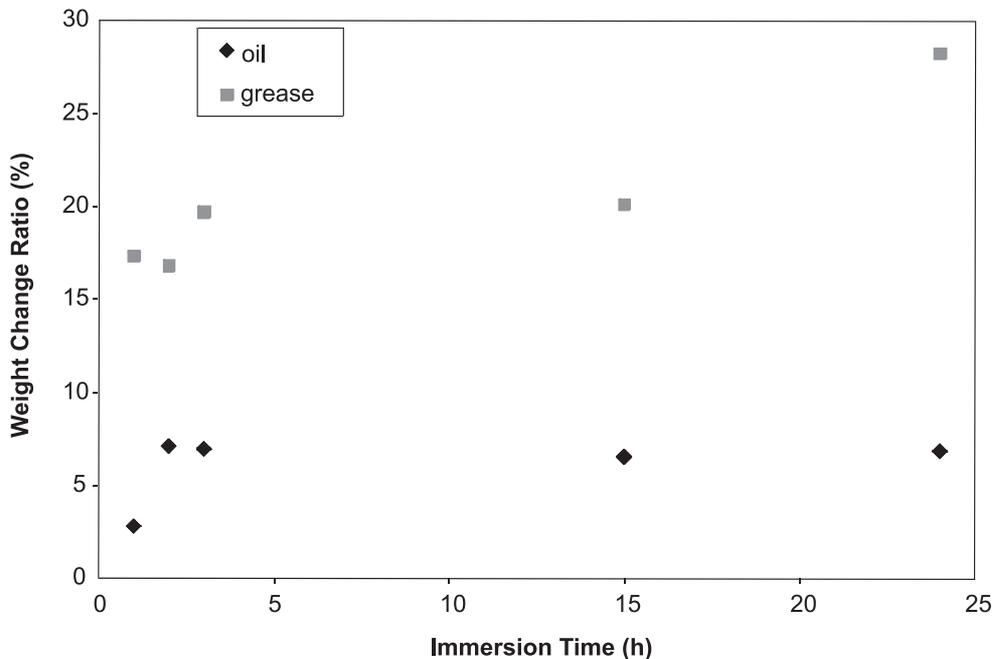

Figure 5. Variation of weight change as a function of immersion time in motor oil and grease for disposable nitrile rubber glove samples (G5).
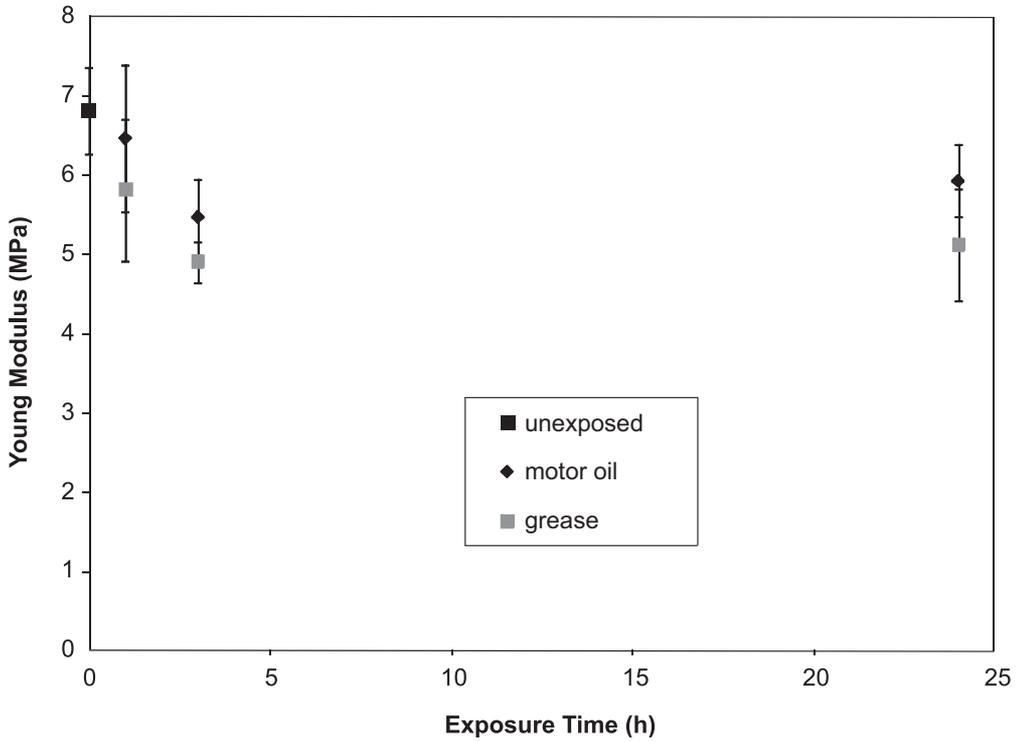
Figure 6. Variation of the Young modulus of disposable nitrile rubber glove (G5) samples as a function of exposure time to motor oil and grease.
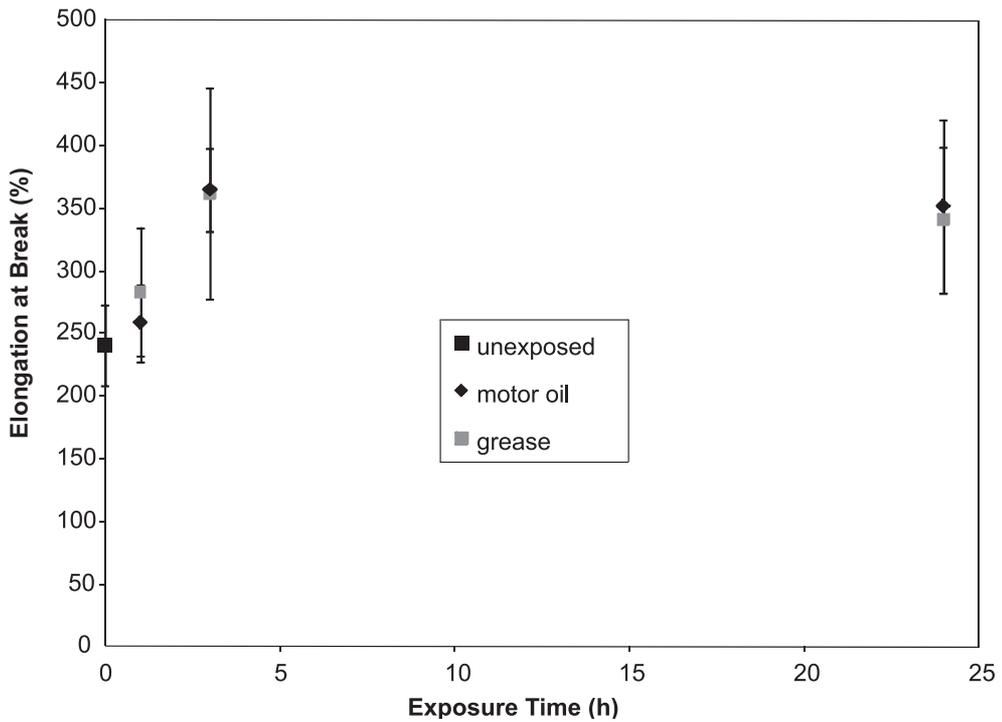

Figure 7. Variation of the elongation at break of disposable nitrile rubber glove (G5) samples as a function of exposure time to motor oil and grease.

Figure 8 displays the results obtained for puncture resistance. Grease-exposed samples display reduced puncture force values compared to unexposed nitrile rubber gloves while no significant effect of motor oil exposure is observed. Since puncture force is related to
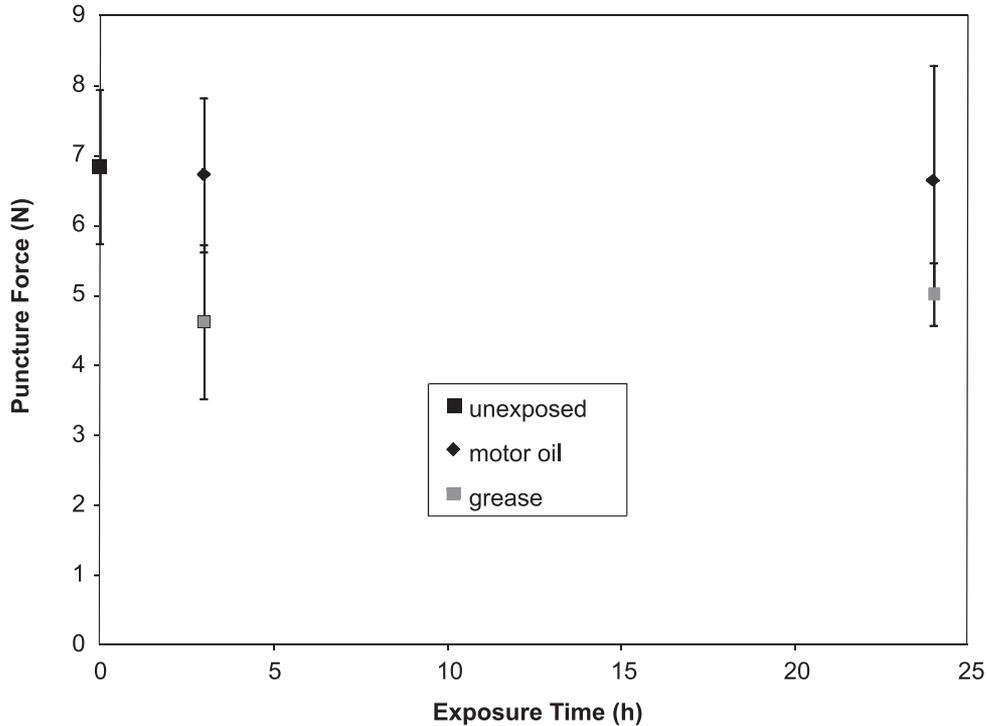
Figure 8. Variation of the puncture force of disposable nitrile rubber glove (G5) samples as a function of exposure time to motor oil and grease.

the material failure stress [27, 28], this effect could possibly be connected to the decrease in mechanical strength of the samples due to the plasticizing action of the penetrating contaminants on the polymer network [10, 11, 13].

3.2. Laboratory Contamination of Reusable Gloves

Five models of reusable gloves were subjected to laboratory contamination treatments in specific oil and grease contaminants (see Tables 1–2 for details) for 1- and 8-h exposure periods. Resistance to cutting, puncture and tearing was measured on contaminated samples as well as on unexposed material. Table 3 presents the results of the measurements for these reusable glove models, the corresponding contaminants and the two exposure times. They are expressed in terms of the percentage of variation for each property: $(R - R_0)/R_0$, with R and R_0 respectively the resistance of exposed and unexposed material. It must be noted that, depending on the measured property, the lowest values of variation observed ($\leq 10\%$) may lie within the uncertainty of the measurement technique and the variability brought by the tested materials.

In some instances, large effects of laboratory exposure to oils and greases on the resistance to mechanical risks can be seen for some glove/contaminant couples. For example, a reduction in cut resistance of 22% after 1 h of exposure and 38% after 8 h was measured in the case of nitrile rubber coated cotton knit gloves (G1) in contact with a cutting fluid. For polyurethane coated Dyneema® knit gloves (G3) exposed to a metalworking lubricant, the puncture force was reduced by 44% after 1 h of exposure and 59% after 8 h. Large modifications of glove tearing resistance following exposure to oil and grease contaminants were also sometimes measured. Even if the laboratory contamination procedure did not pretend to simulate real glove occupation use conditions, these results clearly demonstrate the importance of the impact of exposure of protective gloves to industrial contaminants on their resistance to mechanical risks. In addition, since a corresponding change in the glove aspect may not always be visually obvious, this may lead to serious safety breaches, with workers not aware of the diminished protection offered by their gloves.

TABLE 3. Variation in Resistance to Cutting, Puncture and Tearing Due to 1–h and 8–h Laboratory Exposure of Reusable Gloves to Various Contaminants

Glove	Contaminant	Cut Resistance (%)		Puncture Resistance (%)		Tear Resistance (%)	
		1 h	8 h	1 h	8 h	1 h	8 h
G1	hydraulic oil	−10	−6	−20	−15	+30	+7
	cutting fluid	−22	−38	−17	−58	+58	+39
G2	cutting spray	+25	+13	−23	−30	+8	−5
G3	metalworking lubricant	−8	−3	−44	−59	+10	−10
G6	motor oil	+24	+24	+4	−7	−11	+8
	bearing grease	+28	+32	−11	−22	+10	+10
G8	motor oil	−1	−7	+18	+19	+2	+21
	bearing grease	+12	−1	+7	+10	0	+3

TABLE 4. Variation in Resistance to Cutting, Puncture and Tearing Measured on Retired Gloves

Glove	Activity	Cut Resistance (%)	Puncture Resistance (%)	Tear Resistance (%)
G4	meat processing	−17	−18	−27
G7	automotive workshop	−8	−25	−34
G8	automotive workshop	+270	−11	+8

3.3. Retired Gloves

The residual resistance to cutting, puncture and tearing was measured on the three glove models for which retired specimens were obtained (G4, G7, G8 in Table 1). Table 4 presents the results in terms of the percentage of variation compared to the properties of new specimens, $(R - R_0)/R_0$. It can be observed that, with the exception of the cutting resistance of synthetic leather, the variations in performance remain lower than 35%. In some cases, the measured variation values are within the uncertainty of the measurement technique and/or the production variability.

In the case of the unsupported nitrile rubber gloves which were used in a meat processing center (G4), the differences in performance are significant only for puncture and tearing. Indeed, due to the low value of nitrile rubber cutting resistance, the measured variation is situated below the precision limit of the method. On the other side, the trend observed for puncture, i.e., a decrease in resistance, is similar to what had been obtained for disposable nitrile rubber gloves exposed to automotive contaminants (Figure 8). However, in addition to the possible lubrication and plasticizing effects associated with contact with animal fat, these retired

gloves may also have sustained mechanical and chemical degradation. In particular, and even if this could also be due to variability at the production level, a slight change in glove color was noted for used gloves. All these phenomena may have contributed to the measured decrease in performance of used gloves.

The same type of behavior can be observed for the retired nitrile rubber coated nylon knit gloves (G7), i.e., a nonsignificant effect on cutting force and a decrease in puncture and tearing resistance. However, in that case, the degradation of the gloves is more obvious. As can be seen in Figure 9, a strong change in color can be observed both on the outside nitrile rubber coating surface as well as on the inside of the glove. The nitrile rubber coating also appears to have experienced pore formation. These may be the sign of a chemical degradation process attributable to contact with automotive contaminants as well as to cleaning chemicals among others.

In the case of the retired synthetic leather gloves (G8), a major increase in resistance to cutting was measured while no significant changes were observed for puncture and tearing. An effect on cutting of such an amplitude cannot be attributed to lubrication since changes measured during laboratory contamination experiments with the
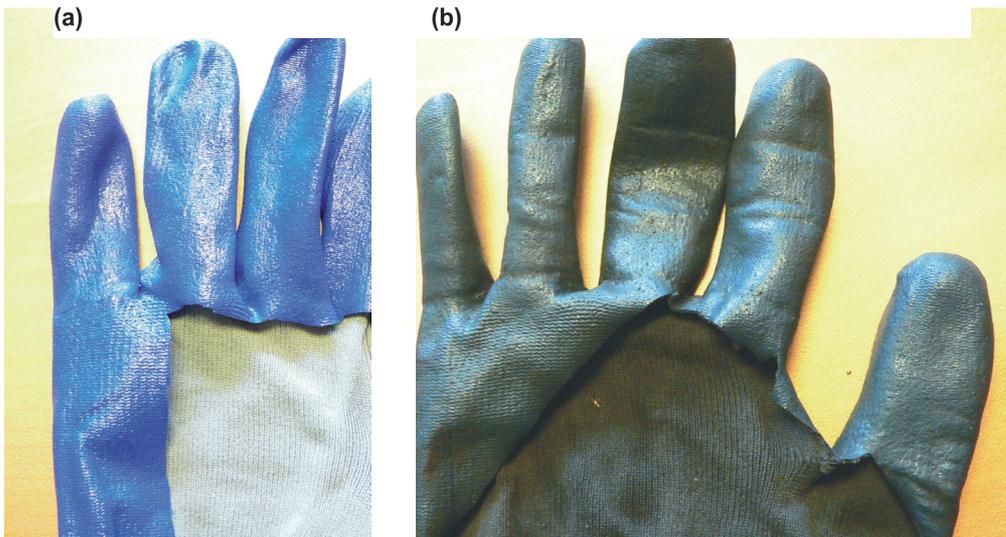
Figure 9. Pictures of (a) new and (b) retired nitrile rubber coated nylon knit gloves (G7) used in a truck workshop showing both the inside and the outside surfaces of the gloves.
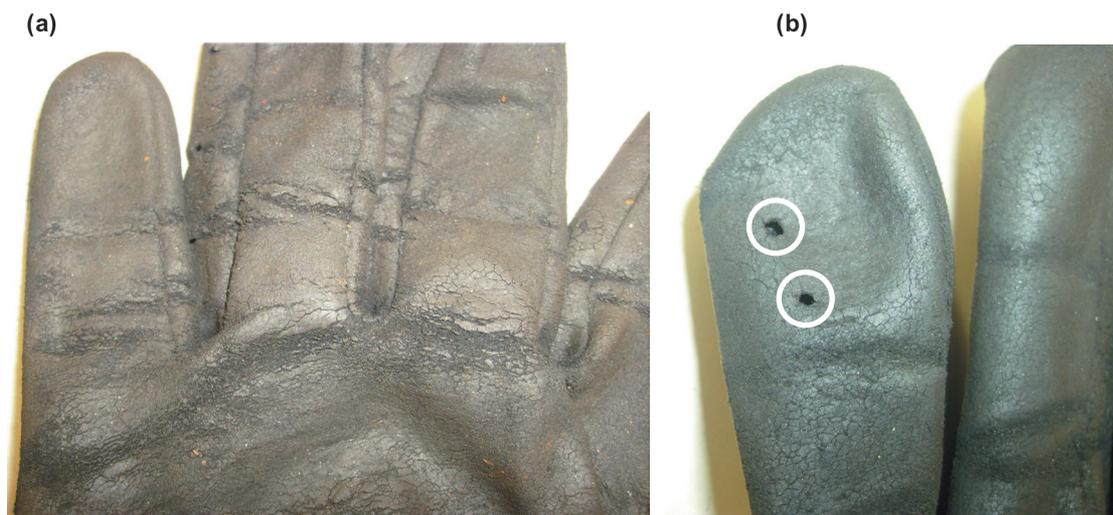

Figure 10. Pictures of the retired synthetic leather gloves (G8).

same glove model and automotive oil and grease were nonsignificant or very limited (Table 3). On the other side, retired specimens appeared to be stiff and hard compared to new gloves, as can be seen from the formation of cracks at the surface of the gloves in Figure 10a. Since cutting resistance has been shown with rubbers to increase with hardness [9], the observed hardening of the retired synthetic leather gloves is thought to be at the source of the major effect measured on cutting force. However, it must be noted that, even if it may increase the resistance to cutting of the gloves, that high stiffness could

have a negative impact on the functionality of the gloves, impairing manual performance and inducing excessive muscular fatigue [29]. In addition, despite the large increase in cutting force measured in the palm section, some areas of the gloves, e.g., those subjected to frequent bending like knuckles, may display a reduced resistance to cutting, in particular at the location of cracks (Figure 10a). The same comment holds for puncture and tearing. Figure 10b is another example of a degraded area and shows the presence of holes in the glove.
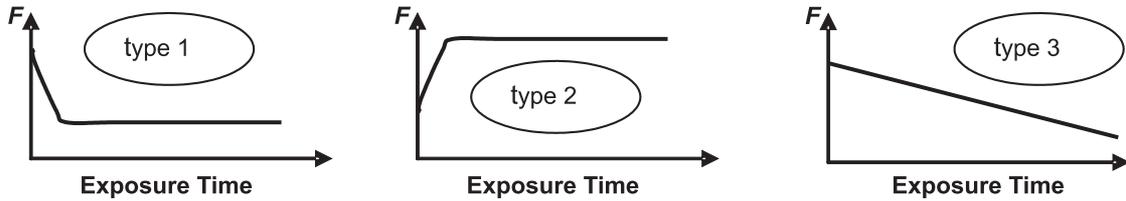
Figure 11. Schematic representation of the 3 types of time profiles corresponding to the variation of the measured glove resistance properties as a function of exposure to contaminants.

4. DISCUSSION

Despite the small number of studied conditions, which limits the extent of the investigation, an exploratory analysis of the effect of oil and grease contamination on the mechanical resistance of the gloves was performed. First of all, it appears that the time-variation of the measured properties generally follows one of three profiles: a sharp decrease from the original value, followed by a plateau; a sharp increase followed by a plateau; and a gradual decrease. They are illustrated in Figure 11. The first two types of behavior (types 1 and 2 in Figure 11), in which the force appears to be independent of the exposure time, may be attributed to an effect of lubrication of the sample surface by the contaminant. As a matter of fact, a lubrication-induced reduction in friction was put forward to explain the decrease in cut resistance observed with neoprene contaminated by a cutting fluid [9]. On the other hand, because of its time-dependence, the third type of behavior (type 3 in Figure 11) could possibly be linked to a progressive modification of the material and of its mechanical strength by the contaminant. The action may be physical, the penetrating contaminant playing the role of plasticizer within the polymer network [12, 15] and reducing the stiffness of the material, to which, e.g., the cut resistance of rubbers has been shown to be proportional [9]. The process could also be chemical, with a degradation of the polymer intermolecular bonds by the contaminant components [11, 13]. It must be noted that these surface (lubrication) and volume (physical/chemical modification) processes may happen simultaneous depending on the nature of the glove material and contaminant.

In regards to the contamination-induced lubrication effects on cut resistance, both type 1 and 2 behaviors may be related to the friction contribution to the cutting process. Indeed, it has been shown to involve two components with opposite effects on the cutting force [28, 30]. As illustrated in Figure 12, the lateral component is due to material contact with the sides of the blade, whereas the other one is related to friction at the cutting edge. Friction with the blade sides increases the resistance to cutting while the contribution at the cutting edge lowers the cutting force. Type 1 behavior for cut resistance may thus be related to a predominating effect of lubrication on the blade sides while type 2 profile could be linked to a reduction of friction at the cutting edge.
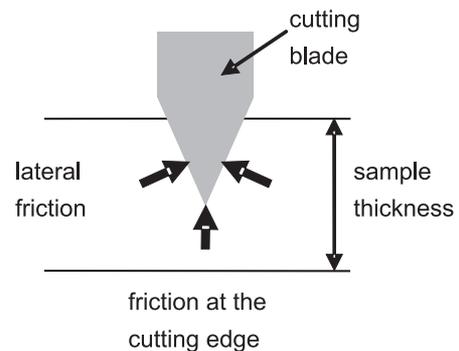

Figure 12. Schematic representation of the 2 contributions of friction to cutting.

In the case of puncture, the force has been shown to depend on the contact surface between the membrane and the probe tip [27, 28]. However, the effects of lubrication are thought to be small compared to the contribution of the reduction in mechanical strength due to the plasticizing action of the contaminants [31].
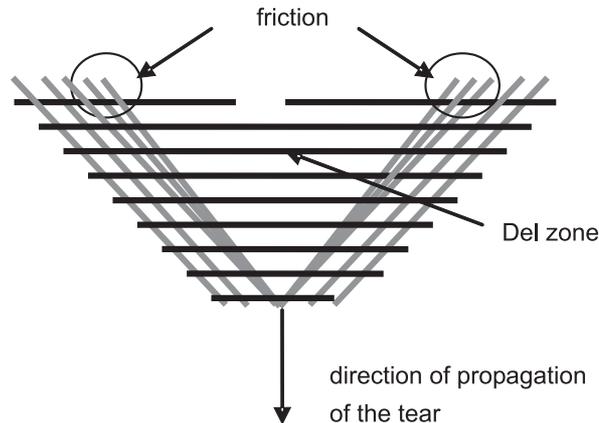
Figure 13. Schematic representation of the tearing process in textile structures.

Finally, an increase in tearing force was observed with some supported gloves as a result of exposure to contaminants. This effect may possibly be attributed to a lubrication of the knitted support yarns by contaminants having penetrated through the coating layer. A reduction of the friction coefficient between longitudinal and transverse yarns at the edge of the Del zone (Figure 13), which is formed during the tearing of textiles [32], would thus allow an increase in the resistance to tearing. The cases of decrease in tearing resistance as a result of exposure to contaminants could rather be attributed to a phenomenon of physical and/or chemical degradation of the material.

5. CONCLUSIONS

This study has looked into the effects of oil and grease industrial contaminants on the resistance to mechanical risks of protective gloves, with a special focus on three sectors where both types of hazards often coexist: metalworking, automotive mechanics and food processing. Laboratory exposition to contaminants was carried out for 1- and 8-h periods. Residual resistance to cutting, puncture and tearing was measured according to standard test methods and compared to the performance of unexposed specimens. Tests were also performed on retired gloves.

In some instances, results showed large differences in resistance both in the case of laboratory contamination and for retired gloves. For example, reductions in resistance to cutting and puncture of respectively up to 38 and 59% and increase in resistance to tearing of up to 58% were measured for some gloves as a result of laboratory exposure to oils and greases. Since visual signs of these changes in the glove mechanical resistance may not be obvious, serious safety breaches may occur for workers. For their part, retired gloves displayed a reduction in performance against the three tested types of mechanical risks of up to 34%, except in the case of retired synthetic leather gloves where a major increase in resistance to cutting was measured. However, it was associated with a stiffening of the material which could be the source of impair manual performance. Two phenomena, surface lubrication and physical/chemical degradation of the glove material by the contaminant, have been tentatively proposed to explain these changes in performance.

This exploratory work indicates the severity of the combined exposure of protective gloves to mechanical risks and to oil and grease-type industrial contaminants, and demonstrates the need to further the research in this domain. In particular, a more systematic analysis should be carried out based on the different types of glove materials and structures and on the various chemical categories of oil and grease industrial contaminants. Finally, some reusable protective gloves may undergo laundering or dry cleaning, which may also affect their mechanical performance. Some research should be done as well into that area.

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