Forest yard's safety: a methodological approach for the analysis of occupational risk

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In the realization of wood biomass thermal plants, environmental sustainability is best achieved through the small-scale plant's adoption. Their needs can be ensured by the surrounding forest resources. This involves, at equal output power, for the environmental and safety control systems a greater economic burden compared to large-scale systems based on massive financial investments. The aim of this study is to define a methodology analysis for the identification of safe and environmentally sustainable work's practices. The methodology will be applied initially to the forest yards, corresponding to the first phase of the forest – wood – energy cycle, i.e. the raw material procurement. The different steps of Hazard Identification, Risk Analysis and Risk Assessment have been applied to the occupational safety of a case study representative of an alpine valley's wooded area. In this analysis have been taken into account the standard operating conditions. The presence of functional anomalies was, instead, analysed by applying a Design FMECA to a forestry plant of timber's handling.
Keywords: *forest-wood-energy, forest yards, occupational safety, environmental sustainability, risk analysis.*

Sicurezza nei cantieri forestali: approccio metodologico all'analisi del rischio occupazionale. *Nella realizzazione di impianti termici a biomassa legnosa, la sostenibilità ambientale è meglio realizzata con l'adozione di impianti di piccola taglia il cui fabbisogno possa essere garantito dalle risorse boschive presenti nel territorio circostante. Ciò comporta, a pari potenza utile, per i sistemi di controllo ambientale e di sicurezza un onere percentualmente maggiore rispetto a impianti di grandi dimensioni, basati su investimenti economici imponenti.*
Obiettivo di questo studio è la definizione di una metodologia di analisi per l'individuazione delle procedure operative più sicure e ambientalmente sostenibili, applicata in prima analisi ai cantieri forestali, corrispondenti alla prima fase del ciclo bosco – legno – energia, ovvero il reperimento della materia prima. Le diverse fasi di Hazard Identification, Risk Analysis e Risk Assessment sono state applicate ad un caso studio rappresentativo di un contesto boschivo delle valli alpine. In tale analisi sono state prese in considerazione le condizioni operative standard. La presenza di anomalie funzionali è stata invece analizzata applicando un Design FMECA ad un impianto forestale di movimentazione del legname.
Parole chiave: *bosco-legno-energia, cantiere forestale, sicurezza occupazionale, sostenibilità ambientale, analisi del rischio.*

Sécurité dans les chantiers forestiers: une approche méthodologique pour l'analyse des risques professionnels. *Dans la construction de centrales thermiques utilisant la biomasse de bois, la durabilité environnementale est mieux assurée grâce à l'adoption de petites centrales dont les exigences peuvent être garantis par les ressources forestières dans la région environnante. Cela signifie que, à puissance de sortie égale, les systèmes de contrôle de l'environnement et de la sécurité constituent une charge pourcentage supérieur à celui qui on a pour grands systèmes, basée sur des investissements économiques imposants.*
Le but de cette étude est de définir une méthode d'analyse pour l'identification des procédures de travail plus sûres et respectueuses de l'environnement, au début appliquée aux chantiers forestiers, correspondant à la première phase du cycle forêt – bois – énergie ou la récupération de la matière brute. Les différentes étapes de l'analyse des risque, l'identification des dangers et évaluation des risques ont été appliquées à un environnement boisé des vallées alpines. Dans cette analyse ont été prises en compte les conditions normales d'exploitation; la présence d'anomalies fonctionnelles ont été analysées avec l'application d'un Design FMECA à un système de mouvement en forêt de bois.
Mots-clés: *forêt-bois-énergie, chantiers forestiers, sécurité au travail, durabilité de l'environnement, analyse des risques.*

1. Introduction

Environmental sustainability is a key point of Horizon 2020, the framework programme for Research and Innovation signed by the European Union. To aim at this goal the use of systems for producing energy from renewable sources, including woody biomass, has been promoted. The main sectors by which this goal can be achieved are forest resource's sustainable management, waste reducing in wood use, biomass energy use to conserve fossil fuels, as well as the increased wood use in building materials.

Each single branch of study is reinforced when the wood/energy chain's management is linked to lines of intervention focused on the territories (i.e. use of secondary raw materials, such as sawmill's processing waste, and, especially, zero-mile products). In order to minimize the distances between the biomass production areas and the energy generation systems, is strongly preferred to design generation plants whose the size is proportional to the production capacity of the surrounding area.

In order to achieve these goals, companies, often small, locally operating must continually evolve to meet the criteria of environmental sustainability, but also to ensure workers safety (Floyde, Lawson, Shalloe, Eastgate and D'Cruz, 2013). In fact, the adoption of small-scale plants leads, in proportion, to a greater economic burden for the environmental and safety control systems than large-scale systems based on massive financial investments.

The aim of this study is to define a methodology analysis for the identification of safe and environmentally sustainable assessment procedures for small thermal plants. The methodology will be initially applied to the forest yards, corresponding to the first phase of the forest – wood – energy cycle (i.e. the raw material procurement).

2. Literature review

The best sustainable choice regarding woody biomass thermal plants is the construction of small plants where the needs of wood can be guaranteed by the forest resources in the surrounding area. Although less efficient than large plants they can offer a better environmental balance, especially if combined with district heating. The maximum optimization of the wood-energy chain should see as the main input the processing waste of activities using wood biomass. This applies to the processing waste of tree harvesting, pruning and woodworking. The material thus recovered is still categorized as waste and, for this reason, is becoming, sometimes, difficult to manage both for use and transport, with regard to the legislation (Carosso, Fea, Luceri e Parola, 2009).

Even if the waste reuse is impossible, the compliance with the zero-mile and the short chain criteria is always important. The European Commission (2011/0282 (COD)) has defined the short chain as a supply chain consisting of a limited number of traders. They commit themselves to promote cooperation, local economic development and narrow geographical and social relations between producers and consumers. A thorough review of short chain definitions (Fondse, M., Wubben, E., Korstee, H., Pascucci, S., 2012.) identifies four essential criteria for its definition: the environmental sustainability, the geographical proximity between producers and consumers, the ability to generate added value and local scale profits, the social equity and balanced redistribution of value along the chain. Regarding biofuels (Directive 2009/30/EC), the chain should respect sustainability criteria so that the energy from these products can contribute to the national target's achievement on renewable energy. Even for woody biomass from forests there are initiatives to provide guarantees for the supply chain's sustainability and transparency towards the market. To be mentioned, among others, the certification according to the Forest Stewardship Council standards (FSCsc) and the Programme for the Endorsement of Forest Certification scheme (PEFC) about sustainable forest management and product traceability along the supply chain. Moreover, technical standards define the characteristics and the quality classes of different solid biofuels (UNI EN 14961) and criteria for control and quality assurance (UNI EN 15234). The woody biomass production and his energetic utilization in local scale, if realized by applying quality standards, is also an important way to develop rural areas. It is possible achieve economic, social and environmental targets by maintaining vital rural areas, braking and reversing the phenomenon of depopulation and contributing on the improvement of the quality of life. The forest has a paramount importance role for the soil's hydrogeological protection and for the preservation of landscapes and air quality. Since the work takes place in a wooded area, which is generally highly sensitive to environmental impact, it is essential to find ways to limit as much as possible the impact on the surrounding environment (Van Belle, 2006) (Wall, 2012) according to the principle of sustainable forest management. The Sustainable Forest Management certification, recognized by an independent certification agency to a forest's owner or manager, states that the forest management complies with a certification standard (www.pefc.it).

The optimal forest yards management implies that, as well as environmental safety, also job safety has to be taken into account (Montorselli, Lombardini, Magagnotti, Marchi, Neri, Picchi e Spinelli, 2010). The use of zero-mile biomass can present major problems in terms of overall safety management. In fact, s already stated, safety costs are usually higher for small plants. In addition the safety management of small forest yards, a common condition for this type of production, is affected by the limited financial resources of the small companies, the difficult to reach the site and, often, by the critical morphological characteristics of the parcels (i.e. altitude, incline, soil). Therefore, those characteristics of the surrounding environment influence heavily the safety conditions, constraining the choice for the procedures to be followed. For this reason, the work should be carefully planned, in order to identify technical and economical suitable workplace's procedures, to ensure the workers and the environmental safety.

Forestry activities may be distinguished (Hippoliti, 1994) in narrowly forestry activities and so-called activities because of the environment in which they are carried out, but charged to other components of the forest system (soil, civil infrastructures, etc.).

When analyzing the European legislation on safety (Directive 92/57/EEC, Annex I) the forestry activities do not explicitly appear among construction sites activities.

In Italy (D.lgs 81/08, Annex X), forest yards are considered construction sites exclusively when they involves building or civil engineering works. Forestry activities in the strict sense are not included in this definition, even though they are clearly distinct by yard's peculiarities, especially regarding the workplace's variability that can not be handled only according to the rules of D.lgs. 81/08's Title II. Despite the considered activities do not formally fall within the scope of D.lgs. 81/08's Title IV, minimum rules must be met. In this sense, the revision of Risk Assessment Document (DVR) in case of work environment's significant change, responds to a safety's need (D.lgs. 81/08, article 29, paragraph 3). This document must be adapted yard for yard (or at least for environment's type) charged to who uses the forest and takes the employer's role (D.lgs 81/08, Article 18). If the wood's owner is not the logger itself, logging activities will be subject to contract, in particular in case of public forests where the owner is the municipality or other local government.

There is a need, in the public or private contract, to achieve cooperation and coordination between the figures involved in the contract (i.e. enterprises and self-employed workers) in order to organize the overall work and service's safety. To handle this, the employer must develop the Interference Risk's Unique Assessment Document (DUVRI). This document shows the operating guidelines that must be performed in order to eliminate or, where that is not possible, to minimize the risks. The DUVRI should be adapted according to the work, supplies and service's evolution and it should be prepared for forest yards with the same methodology as the Safety and Coordination's Plan (PSC) provided for temporary and mobile construction sites. This situation typically occurs when a public body is a forest owner and it entrusts forestry activities to one or more companies.

In areas of particular difficulty or by choice of the client (especially if public) there is the opportunity to ask the company the Operational Safety Plan (POS) and write up the PSC considered as safety's cost.

There is so, on the whole, a complex situation of normative references as regards safety in logging forest yards. Some regions, through regional plans and prevention's guidelines, have begun to define the procedures to be followed to minimize and, where possible, to eliminate forest environment's risks. On the contrary, a procedure defined at national level, for proper and safe management of forestry activities still lacks. Companies with PEFC certification implicitly agree to abide by the national legislation, but, also, in this case a clear reference lacks.

3. *Materials and method*

The main stages of a forest yard (Regione Toscana, 2013) are generally: analysis of the work environment (preliminary survey), yard's preparation, felling, processing, bunching, primary transportation, activity at the landing. Separately there is the transportation to the following stages of processing.

These activities generally defined under the term "logging" can be performed as measures for the conservation and enhancement of forest soil or as activities closer to the timber's harvesting at the end of the crop cycle. These, as part of a proper and sustainable forest management, must be conducted according to the specific forestry procedures and in compliance with several normative requirements. In this way, by a natural cut of the trees or through planting and reforestation, is possible to regenerate the woods after logging. The equipment used in each of these phases depend strongly on the workplace and on the characteristics of the plants to be cut.

The forest yards usually occupy variable size areas which can have orographic and vegetative limits for the work's execution. The transport to further processing yards is strongly influenced by the characteristics of the place where the processing is carried out and the maintenance's state of the forest roads. Forestry activities are characterized by the use of different equipment. For each phase the main sub-phases have been identified and they have been briefly described (Tab. 1).

The techniques and equipments used are depending primarily on some key features such as the lot's inclination, the altitude, the type and quantity of plants to be cut and handled and timber's future uses. Those parameters are strongly influential in the work's environment that often is not the best from the safety's point of view. It is therefore required an analysis method to facilitate the identification of procedures to minimize risks.

To analyze the complex management of works carried out in small and, often, difficult to access forest lots (because placed in mountainous areas), two real cases have been identified and examined. They were chosen to be representative of small thermal plants, located in alpine valley areas next to the forest land that should supply them. To ensure compliance with the environmental sustainability's criteria the examined forestry activities were carried out by a company with certification of sustainable forest management (PEFC).

One of the examined study case is related to the cutting of a wooded lot, located in a town in an alpine valley of North-Western Italy (Fig. 1). It was considered a suitable area, being rich in forestry resources, for the placement of small size heating plants. The lot is located, at an altitude between 970 and 1120 m above sea level and with an area of approximately 4 ha, in a coppice's forest mainly consisting of beechs, sweet chestnuts and mixed deciduous.

Tab. 1. The main processing stages of a forest yard.
Principali fasi lavorative di un cantiere forestale.

Working phases	Working sub phases	Description
Preliminary survey	Observation of the area where the work will be carried out	The preliminary survey, carried out by the employer before the work, is used to identify the characteristics that may influence the selection of techniques, procedures and equipment that will be used in the course of forestry activities.
	Observation of the external environment	
	Observation activities and surrounding human infrastructure	
Yard's preparation	Identification of the perimeter	The employer shall prepare the yard: identifying its perimeter, placing yard's signage, giving communication, in case of obstacles to aviation, to the competent authority and taking the necessary measures, providing the site of required equipment, informing, educating and training the workers on the procedures to be followed in case of emergency. Sufficiently large areas must be identified to maneuver the vehicles, for equipment's temporary storage and for timber's stacking.
	Placement of yard's signage	
	Worker's information, education and training	
	Endowment of machines, tools, plants and PPE	
Felling	Choosing the fall's direction	Felling refers to the tree's cutting off and their knockdown. Before beginning the felling, an examination of the plant to break down is done to better evaluate the most appropriate procedures and needed equipment. If the plant, during the felling, remains entangled with other, it must be landed in the shortest possible time. It can be done manually, using a chainsaw, or through feller.
	Identifying escape route, forbidden zone and danger zone	
	Cutting of the stem	
Processing	Delimbing	The processing includes all the various working phases after tree's felling and knockdown: delimbing, cross cutting and debarking. It can be done manually, using the chiansaw, or clearing saw or through processor.
	Cross cutting	
	Debarking	
Bunching	Identifying bunching's technology	The bunching is the material's handling stage from the felling point to the striproad. During the bunching each piece follows its own path, oriented along the lines of maximum incline on the wood's natural soil, slipping by gravity or being pulled. This step is the most expensive, both in terms of direct costs both of wood and timber's damage. It should therefore be shortened and simplified as much as possible, limiting the covered distance.
	Identifying the bunching's point	
	Timber's handling	
	Timber's bunching	
Primary transportation	Identifying primary trasportation's technology	The primary trasportation occurs along paths specially equipped, the striproads, through which the material is brought up to the log yard, the landing, truck's loading point. The striproads can be permanent or temporary. The distances of primary trasportation are normally on the order of hundreds of meters.
	Locating points for the vehicles's arrival	
	Timber's handling	
	Timber's bunching	
Activity at the landing	Chipping	The work's phases, which cannot be carried out on felling point for reasons related to their mechanization, take place at the landing. The main processes that can be performed at the landing are: chipping (grinding of damaged or defective stem's parts, top end, small stems, branches, sawmill waste, which are ground to small flakes), debarking through machinery and material's loading on the trucks.
	Debarking	
	Loading timber and chips	

During the cutting operations, carried out in the spring-summer 2014/2015, have been felled beechs, sweet chestnuts, mixed deciduous, 37 larches and 25 death plants. The wooded lot has a very steep slope made by difference of 200 m between the highest and the lowest point. Furthermore, the access for vehicles is limited to the stretch of road that runs along the foot of the lot. The choice of the most appropriate operating procedures to be used was made according to these characteristics.

After the identification of the most suitable operational procedures, the individual work phases (i.e. felling, processing, timber's handling, activity at the landing, transport to the valley floor) have been divided into sub-phases. For each elementary processing of those sub-phases the main sources of risk have been identified. They were divided into: used equipment, materials (raw and complementary materials, waste and products), work environment and organization. This division has been kept for each risk's source to identify the related hazard's factors, the potential damages, the procedures to be followed for risk minimization and the PPE to be used.

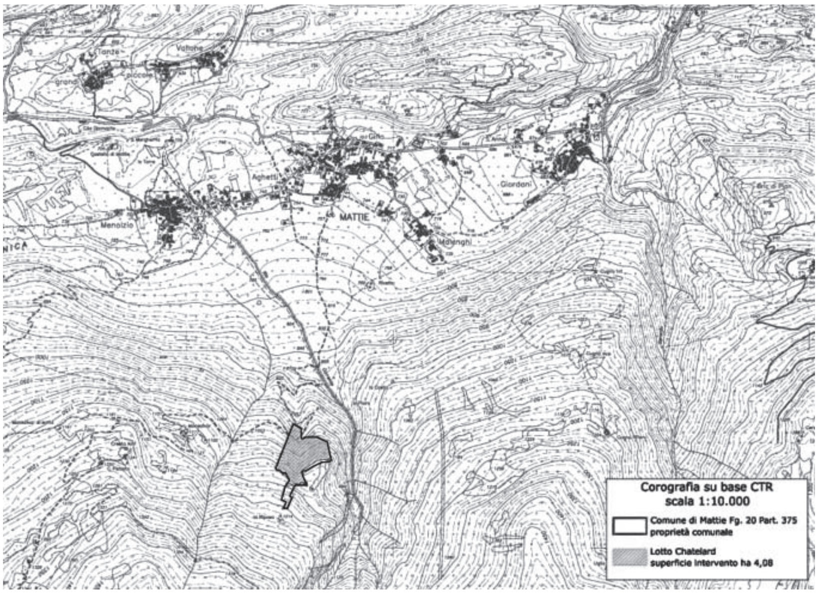

Fig. 1. Wooded lot's extent and location.
Estensione e collocazione del lotto boschivo.

4. Results

The analysis method has been applied as an example to the phase of on-site timber's handling (Tab. 2). Because of the particular lot's conformation it was decided to move the cut timber through yarder. The timber was secured to the hook of the towing cable with steel straps (Fig. 2). The truck by gravity brought the material to the base of the lot where was located the staple for the storage and loading of vehicles. Once the timber has been unloaded, it was stacked with a crawler excavator with hydraulic shears. The work organization requires that a worker starts the winch, another one docks the tree to the towing cable's hook and a third worker unhooks the tree once came to the staple and, after, he has to steer the excavator. Communications between workers are insured through two-way radios.

Each equipment used in forestry activities presents specific hazard's factors that determine the need to adopt procedures to ensure the respect of safety conditions (what is safe in a staple may not be safe in a sloping hillside). To identify the

Fig. 2. Yarder's truck.
Carrello della gru a cavo.

Tab. 2. Sources of danger for the phase of timber's handling.
Sorgenti di pericolo per la fase di movimentazione del legname.

Sub phases	Basic work	Equipment	Materials				Work environment	Work organization	
			Raw materials	Complementary materials	Waste	Products		General	Operating conditions
Handling with yarder	Timber docking	Yarder	Trunks, branches	Diesel fuel, steel ropes			Forest	2 workers	1 worker docks the tree to the rope, 1 worker starts the winch
	Timber lifting								1 worker starts the winch, 1 worker directs the tree's movements
	Timber handling								
	Timber lowering								
	Timber unhooking						Staple	1 worker	1 worker unhooks the tree
Stacking through crawler excavator	Timber lifting	Crawler excavator with hydraulic shears		Diesel fuel					1 worker steers the excavator
	Timber handling								
	Stacking					Timber piles			

hazard's factors and the most appropriate procedures to follow (Tab. 3), reference was made to the essential safety requirements (Directive 2006/42/EC) and the harmonized standards, if they exist. In the examined phase the used equipment was a crawler excavator with hydraulic shears and a yarder.

During the examined phase the workers come into contact with trunks and branches (raw materials), steel ropes and diesel fuel (complementary materials). The methodology above described was applied to the raw materials involved in the timber's handling phase (Tab. 4).

The workplaces of the forestry activities (Fig. 3), specifically wood and staple for storage and loading of vehicles, have their own characteri-

Fig. 3. Work environment.
Ambiente di lavoro.

Tab. 3. Hazard's factors associated with the equipment.
Fattori di pericolo associati alle attrezzature.

Machinery	Hazard's factor	Possible associated deviations and damages	Procedures	PPE
Yarder	Material's fall from a height	Contusions, fractures, wounds, crushing injuries, injuries to internal organs	Maintain safety distances Adopt the correct operating procedures Ensure the stability of the load	Safety helmet Gloves Safety shoes
	Work at height		Adopt the correct operating procedures Bind with appropriate fall protection harnesses	Safety helmet Gloves Safety shoes Fall protection harnesses
	Moving mechanical parts	Contusions, fractures, wounds	Verify the presence of the protection systems Perform maintenance and overhaul following the instructions in the manual	Gloves Fitting clothing
	Flammable liquids	Burns	Do not smoke Do not use open flames Adopt the correct operating procedures for refueling	
	Hot surfaces	Burns from contact	Verify the presence of the hot surface's protection systems Adopt the correct operating procedures	Gloves Protective clothing
	Noise	Hypoacusis, physiological disorders, interferences with verbal communication	Perform maintenance and overhaul following the instructions in the manual Reduce the exposure time by appropriate work's organization	Ear protection
	Vibrations to hands and arms	Raynaud's disease, neuro-sensory and osteo-articular disorders	Perform maintenance and overhaul following the instructions in the manual Reduce the exposure time by appropriate work's organization	Gloves
	Manual handling of loads	Musculoskeletal and articular damages	Take appropriate postures Adopt the correct operating procedures	Gloves Safety shoes
	Awkward postures			

Tab. 4. Hazard's factors associated with the materials.
Fattori di pericolo associati ai materiali.

Materials	**Hazard's factors**	**Possible associated deviations and damages**	**Procedures**	**PPE**
Trunks branches	Unexpected and sudden shift	Contusions, fractures, wounds, crushing injuries	Keep the predetermined positions and safety distances Adopt the correct operating procedures	Safety helmet Safety shoes
	Rolling			Safety shoes
	Whipping	Contusions, wounds	Keep the predetermined positions and safety distances Adopt the correct operating procedures	Safety helmet Gloves Face shield or safety glasses Safety shoes Protective clothing
	Fall and projection	Contusions, wounds, traumatic injuries		Safety helmet Safety shoes
	Manual handling of loads	Musculoskeletal and articular damages	Take appropriate postures Adopt the correct operating procedures	Gloves Safety shoes
	Awkward postures	Muscle and articular pain		

stics compared to conventional work environments (not considered and regulated in the legislation). The procedures to be implemented must therefore take into account these features and adapt from time to time to the different situation (Tab. 5).

The organization of the work involves three operators. The working procedures must have been previously determined and each worker must have his own task (Tab. 6).

Tab. 5. Hazard's factors associated with the work environment.
Fattori di pericolo associati all'ambiente di lavoro.

Work environment	**Hazard's factor**	**Possible associated deviations and damages**	**Procedures**	**PPE**
Wood	High temperatures	Dehydration, thermal stress	Take adequate food and drink Suspend work if appropriate	Breathable clothing
	Weathering	Colds, in the event of lightning, burns and electric shock	Ensure the availability of temporary shelters Take adequate food and drink Suspend work if appropriate	Protective clothing
	Vipers	Poisoning		Gloves Safety shoes Protective clothing
	Wild animals	Transmission of diseases	Make the necessary vaccinations	Gloves Safety shoes Protective clothing
	Insects	Local reaction, anaphylactic shock, skin, eye and respiratory tract's irritation	Make the necessary vaccinations Use specific repellents	Gloves Safety shoes Protective clothing
	Shrubs and brambles	Contusions, injuries, infezioni	Make tetanus vaccination	Gloves Safety shoes
	Trunks and rocks rolling	Contusions, fractures, wounds, traumatic injuries	Adopt the correct operating procedures	Safety helmet Safety shoes
	Slips and falls	Contusions, distortions, fractures, musculotendinous injuries, wounds	Adopt the correct operating procedures	Safety shoes
	Instability of the slope	Injuries	In the event of excessive rain, suspend the processing Adopt the correct operating procedures	
Staple	Investment	Contusions, fractures, injuries	Maintain safety distances Adopt the correct operating procedures Observe the yard's mobility	

Tab. 6. Hazard's factors associated with the work organization.
Fattori di pericolo associati all'organizzazione del lavoro.

Work organization	Hazard's factor	Possible associated deviations and damages	Procedures	PPE
3 workers	Failure to comply with the work organization	Interference with other processes, incorrect load's handling	Observe established breaks and the forecast work's rotation Respect the timetable imposed by the employer	
	Work-related stress	Stress, psychological disorders		

5. Discussion

The applied methodology made possible the management of a whole "yard's system" in all its complexity, which is necessary for effective Prevention Through Design (Borchiellini, Cardu, Colella, Labagnara, Martinetti, Patrucco, Sandrin e Verda, 2013). The starting point was work's organization and after the various stages, it was achieved the construction of detailed sheets for equipment, material and environment. This analysis scheme determined the correct Hazard Identification in standard operating conditions considering mainly the regular productive cycle. Regarding Risk Analysis (Patrucco, Bersano, Cigna e Fissano, 2010) and Risk Assessment (Patrucco, Labagnara, Coggiola e Pira, 2011), the occurrence's probability, the damage's magnitude and the contact factor can be quantified for each individual elementary processes which constitutes phases and sub-phases and applying the Job Safety Analysis (JSA). Therefore the risk associated with the elementary processes, can always be obtained in standard operating conditions. To assess what can happen under fault conditions, the Failure Modes Effects and Criticality Analysis (FMECA) has been applied experimentally to the forestry activities. The FMECA is a technique of Hazard Identification (Stamatis, 1995) mainly applied to the process industries. The different stages of processing was considered as subsystems and as a first step the method was applied at the equipment identified in the system's analysis.

The main scope of the analysis is to identify the relationships between the individual failure's scenarios and the propagation of deviation to other involved machines.

For each subsystem all the possible failure modes, causes, effects and controls are listed. The damage is assessed on the basis of the consequences, which are classified into four categories of decreasing severity: I (catastrophic), II (critical), III (boundary condition), IV (tolerable). The frequency is classified into five categories: E (extremely remote), D (remote), C (occasional), B (reasonably likely), A (frequent). The occurrence's probability, the effect's severity and the possibility of detection by controls are evaluated for all combinations failure modes – cause. The realization of the FMECA requires the collaboration of a multidisciplinary team of experts to have an extensive knowledge of all aspects that may affect the plant's functioning. For this reason, during the study different subjects with specific expertise were consulted. In addition to consulting design and historical machine's data, reference was made to specific technical standards, if they exist (UNI EN 12385-1: 2009, EN 12385-4: 2008, EN 14492-1: 2009, EN 14492-2: 2009), and in any case the safety requirements and guidelines of the Machinery Directive.

The table (Tab. 7) shows an example of the methods of the analytical method applied to the yarder's winch, which could be used in general for machinery and equipment used in forestry activities.

6. Conclusions

The study conducted has shown that forestry activities have the yard's typical characteristics to be carried out in different environments, that require the application of the Risk Assessment Document for each workplace's change. In order to define scenarios aimed at occupational and environmental safety, some productive cycles were examined by applying different techniques of Hazard Identification. The method has described and identified every hazard's factor from the main cause of risk (i.e. materials, equipment, environment and work organization) for each phase and sub-phase. It has allowed the management of the whole yard's system in its complexity in operating standard conditions. For the analysis of deviations from these conditions, the work has involved the Design FMECA's application to a system for timber's handling. In order to control the entire production cycle in different operating conditions and to evaluate eventual interactions with the environment, the adoption of a Process FMEA is under study. This will be done alongside the experimentation of other Hazard Identification's techniques enabling a better understanding of the environmental and occupational risk.

Tab. 7. FMECA's application to the yarder's winch.
Applicazione della FMECA all'argano della gru a cavo.

Subcomponent	Component's function	Failure modes	Failure causes	Local effect	Effect on the system	Detection mode	Corrective action	D	F
Control devices	Start and stop winch	Break up	Usury	No interruption of the power supply to the release of the drive elements	Plant's failure to stop	Functional test Visual inspection	Emergency stop Maintenance	III	C
			Lack of maintenance					III	C
Emergency stop function	Stop in case of emergency	Not operational	Usury	Failure to stop in case of emergency			Maintenance	II	C
Barrel	Rope winding on the barrel	Rope's release from the barrel	Lack of barrel's flanged ends	Uncontrolled rope's movement	Load's fall	Visual inspection	Flanged barrel's end Emergency stop	III	D
		Breaking anchoring system	Usury	Loss of control of the rope		Maintenance	Emergency stop	III	C
			Overcoming traction force			Calculation's control		III	D
Rope sheaves	Movement's transmission to the rope	Release of the cable from the grooves	Loosening of the rope	Uncontrolled rope's movement		Visual inspection		III	B
Engine	Energy converter	Overcoming traction force	Excessive power transmission	Ropes break up	Uncontrolled rope's movement	Calculation's control		II	D
		Break up	Usury	Failure to transmit the movement to the rope	Activity's stop	Periodic check	Maintenance	II	C
			Lack of maintenance					II	C
Disc brakes	Slowing rope's movement		Usury	Failure slowdown of the rope's movement	Uncontrolled rope's movement		Maintenance Emergency stop	III	C
			Lack of maintenance					III	C

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