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RAIL TRAFFIC SAFETY. CASE STUDY: RUPTURE OF COUPLING

BY

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Abstract. In the railways, to make our trains safely, a set of agents such as department head, traction, and conductor participates in this mission. These officers belong to four different services, but despite the heterogeneity of the elements in the group they work in synergy, they have a same concern, namely the safety of passengers and goods transported. What we seek to promote, through this article, is that the safety of rail traffic is based on legislation enough stuff and that the profession of railroader belongs to a well structured organization. It effectively describes the routine activity of each worker, responsibilities in its position and the role in the organization. It offers a favourable environment of trust, training and coordination.

Key words: rail safety, collective performance, risk management.

1. Introduction

The railway is a system of guided transport used to transport people and goods. It consists of a specialised infrastructure, rolling stock and operating procedures involving it more often human. One of the basic principles which

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form the basis of all the activities carried out by the SNTF (Société Nationale de Transports Ferroviaires, i.e. -National Railway Transport) is the safety of the traffic of trains. The main "actors" of the security are the head of Department, the command officer, the switchman and the conductor of traction. All these are armed with a collection of fairly extensive procedures and organized instructions regarding the railway operation regulations, thus, forming a homogeneous and consistent set to facilitate the exercise of the function of traffic safety.

2. Security of the Railway Traffic

Railway safety is a process designated to preserve the safety of railway operations and to avoid scenarios leading to incidents and accidents that may cause loss of human life and damage to railway. Traffic safety manager is required to ensure rail safety and remain vigilant by observing standards of security, based on useful knowledge for the sustainability of the daily security.

System forming security focuses on human, safety facilities and procedures. This system regulates and manages the movement of trains. The peculiarity of the safety of rail traffic is that individuals involved in activity should lead this task together even though they do not share the same workplace. What committed means of varied communication (telephone, radio, signals) and the use of specific language. Modernization of signalling, telecommunication and safety facilities is one of the priorities of the railway sector because it affects the reliable and efficient operation of the network.

3. Risk Management

Risk management is so structured and planned as a system for risks prevention by means of a dynamic system. Dynamic risk management system is designed to enable the prevention planning and implementation of policy with respect to the welfare of workers during the performance of their work, well-being of the passengers during their trip and the preservation of the goods being transported. It is dynamic because it should be perpetually in motion. This is not in fact to make a photograph, a State of play, take a few steps here, there, and then to sleep with the feeling of accomplishment. It is instead put in place a system which is evaluated on an ongoing basis and that always comes back to its starting point. The risk management revolves around four stages, as follows

I. Risk identification by searching for accidents that could occur and the events that portray a normal situation to a potential accident scenario.
II. Risk assessment by the association in each of the events a frequency of occurrence and severity, which can reach in life or financial cost.
III. Selection of the risks that we accept and those that it does not accept and is used for product frequency-severity, called criticality.

IV. Control risks by the choice of risk reduction actions, either to dismiss the risks considered unacceptable, to maintain residual risks within acceptable limits.

4. Different Risks

Risks related to the trains' movement:

a. Nose-to-nose trains: it's a head-on collision between two trains. It is most often due to human error (except on the very old posts, this risk is protected by safety installations).
b. Catching up: unlike the nose-to-nose, there is here a rear-end collision. A train struck another train which lies before him (this risk is protected by the principle of the cantonment).
c. Taken in a sling: it is a lateral collision that occurs at the intersection of routes. For example, a train that is committed on a track on which already runs another train going in the same direction. (Except on the very old posts, this risk is protected by safety installations).
d. Derivative: it can be one or several vehicles (car, wagon) that go on after a failing asset, especially in the presence of a significant slope.

Risks related to the State of rolling stock:

a. Heating of bearing box.
b. Breakdown of axle.
c. Breakdown of bandage wheel.

Fig.1 – Bandage wheel breaking.

Failure of the braking system: this concept does not exist as such, because unlike a road vehicle, naturally freewheel (one must press a pedal for braking), a train brake system is naturally squeezed by an independent control device in air under pressure. In order to advance a train, it should supply air by another system (BPP), pressure causing loosening. In the event of abnormal loosening, a device to isolate the car or the car (which is then held over back), allowing the

convoy to return, possibly to a speed limit based on its new braking characteristics.

Risks associated with the design of the rolling stock:

The material, very old, is not opposing to maintain the traction during braking, impossible thing on almost all types of current traction.

Risks associated with the design of the signalling installations:

Also very rare, these risks are designed to present a security situation in case of failure. Thus, security situations (red light for example) are by power outage, while liberating situations (green light for example) are by power output.

Risks related to the State of the infrastructure

These risks are collapse of a bridge, viaduct, arch tunnel and the platform on which rests the track, including flooding, breakage of a rail, deformation of the running track or flaw in a device of track.

Risks related to human error

Risks regarding the conductor disobeying controls (accidental crossing of a closed stop sign, speeding). Security systems are opposed on most installations.

Risks associated with external elements

Obstacle on the track: risk of collision with an object (car, truck, poured mud, car or train drift) that is located on the route where the train flows or on which it may engage, criminal attack with the planting of bombs.

5. Avoiding Accidents

To avoid any accident, security features have been implemented, as follows:

The cantonment of trains: it is based on the detection of the track occupation; it comes to delimit zones within there may be only a single train.

Signalling: it instructs the driver of the train traffic conditions to allow it to regulate the conduct of the train. It consists in the stop signs, limiting speed or manoeuvre. These signals can be fixed or mobile, luminous or mechanical, permanent or temporary (Fig. 2).

Switches: they allow alternative routes for the circulation of trains.

The conduct of train control: it allows applying the basic principles of security, the maintenance of the free route, the free way, and the insurance to be able to stop the trains.

Fig. 2 –Switches and signage.

SNTF annually is mobilizing substantial financial resources for the training of its agents, to adapt them to the different functions and at the same time raise their qualifications. The railroader is the strong and indispensable system, consisting in the application of procedures and the rational use of the facilities. It has a noble profession of constraints, he shared a concern for security with the railwaymen community, and his work tool is sacred to him.

6. Safety Management

Safety management term refers to our obligation to organise a system enabling to operate the trains safely, to improve collective security level, by increasing the level of security of each agent, follow all of the areas of security and operators, to ensure respect of the completeness of the procedures, monitor the effectiveness of recovery actions following the detected differences see permanently the level of safety in a given place, organize and set the controls to methodically cover the whole of the security system. In the field of security, the trust does not control, any responsible security officer must accept the control and by the same account for the conduct of its business.

The development of skills and culture 'security' simply mean the development of values, belief, attitude, and behaviour aligned. Training, however, is only one of the elements essential to the achievement of the desired behavioural results. On the other hand, the safety management should be part of a process of evaluation in a learning organisation (Code UIC, 2005). The safety management uses the collective competence, which is the set of knowledge and know-how of a group of work resulting from the interaction between its members and put in work to deal with a situation of work (Krohmer, 2003).

Four concepts can contribute to defining the content of the collective qualification: synergy, solidarity, collective operative image and learning (Troussier, 1990).

Safety management finds these benchmarks in the organizational competence, the latter is defined by (Bailly, 2005) as the result of learning group and in particular those which allow the company to know how to coordinate know-how and integrate various technologies. Therefore, they are not easily imitated. Organizational competence is distributed between (Michaux, 2005): individual human factors (individual skills), tacit collective human factors (knowledge and know-how shared, interactions, scenarios phenomena grouped under the name of collective competence), factors related to organizational structures (procedures, roles), material and technical factors (artifacts.).

By its fundamental role in the motivation of its employees and the management of their potentials, manager is an essential source of performance or non-performance in the management of security, it must have managerial skills. 'Managerial competence' is an attribute or a behavioral feature specific, observable and verifiable) (Razouk, 2007). Put into practice, it leads to a better performance of manager. It can be generic or developed in a particular context.

7. Case Study: Breakage of the Coupling

7.1. Introduction

The hitch is the essential body of rowing training. He was at the origin of railway formed by strings. The need for a semi-rigid connection was quickly felt mainly during downturns and braking. It used elements of elastic shock that are buffers.

7.2 Description of the Coupling Screw

Hitch screw is a manual coupling (said to coquille) which includes two links connected by a screw contrary steps: once the links in place on the hooks of each car, tightening the screws is manual. In freight trains, the tension of coupling must be tightened so that the pads are slightly compressed. The maximum length of these trains should not exceed 700 metres (traction units in service not included). The mass towed trains shall not exceed 1 200 tonnes. The minimum breaking strength is fixed at: 850KN for coupling tensioner 1000 KN for the haulage and other bodies transmitting the effort. The mass of the tensioner shall not exceed 36 kg and even, if possible 30kg. Slack length, measured from inside the loop on the tensioner to hitch to pivot the tensioner coupling and pull hook, should meet the following conditions: for tensioners fully unscrewed and the tensioner screw at bottom. It is intended for the tensioner to hitch a device preventing the spontaneous release of the latter.

Each end of the vehicle must be equipped with a device to suspend the ratchet coupling when not in use. This device must be designed in a manner such that no part of the suspended tensioner can get off less than 140 mm above

the level of the top of the rails, in the lowest qualifying position of buffers (Fig. 3) (Code UIC, 2003).

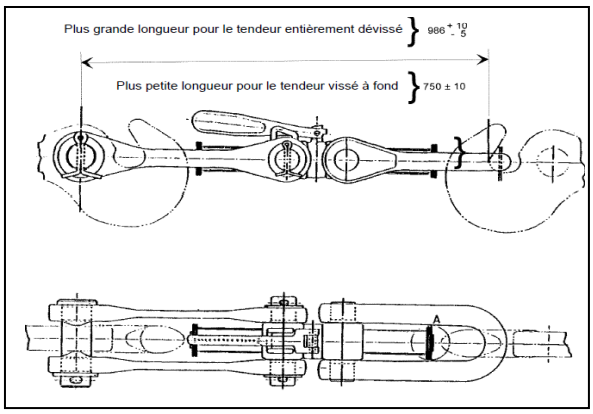

Fig. 3 – Car and van hitch standard screw in handle articulated with higher anti-desirability rest.

7.3. Provisions Relating to Staff

Staff assigned to the tasks related to the formation, composition, and the conduct of trains must receive training that meets the requirements of each of the areas of activity and responsibility involved, and adapted to the corresponding tasks. Staff to intervene on equipment rolling stock (maintenance officer) and use it must receive training adapted to the techniques and the constraints of the operation.

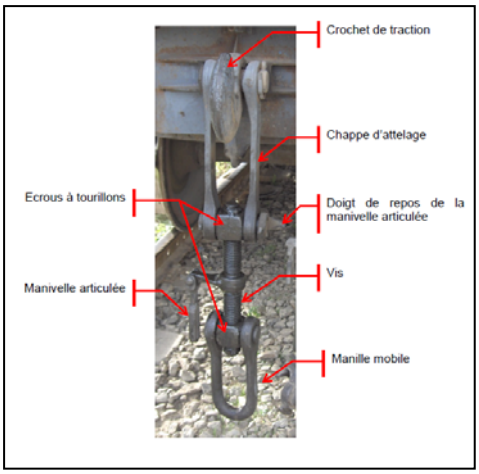

Fig. 4 – The different parts of the coupling.

The staff responsible for audits of equipment (visitors) and loads must be trained in the corresponding tasks and receive helpful instructions. The formation and composition of trains (male team) staff must receive training responding to tasks and the responsibility for these activities. Staff assigned to a security task (Chief) must have a clearance to exercise its powers. It must in particular be able to distinguish the peculiarities that attach to each vehicle and be able to detect any anomaly concerning the equipment or loads. For each category of train, operational documents must give staff from the point of view of safety equipment including the duties to be performed.

7.4. Load of Trains

The load of the trains is part of the rules of composition. Limit not to exceed a value is set for each category of trains and by section of line. The calculation of this limit value is the result of taking account of the following elements, and their interaction:

- The gross weight of each vehicle can be towed,
- The maximum number of these vehicles,
- The limit of resistance of the run-in,
- Mode of traction and conditions of trailer,
- The characteristics of the infrastructure, in particular the declivities and resistance in the way and structures,
- The expected performance based on the nature of transport,
- Dynamic effects related to traffic in convoy. The thus defined limit value is communicated to the appropriate staff in the technical documents.

Fig. 5 – Two cars coupled.

7.5. General Principle of Railway Braking System

The basic principle of the rail brake is to pass the braking instructions issued by the driver through a pressure variation in a pneumatic travelling the length of the train. This conduct is called driving brake General (CG). An air pressure at 5 bar in this line corresponds to the State of the brake disengaged. Any drop in pressure across this conduct led to a commissioning (clamping)

brake throughout the train. This device generates an automatic braking when damage involving the tightness of the CG (e.g. in the event of breakage of the coupling). Compressed air is produced by a compressor arranged aboard the driving (locomotive) General Conduct (CG) through the train, feeds the brake reservoirs and transmits pressure variations of command for tightening and loosening. The agent driving the brake causing pressure variations in the CG through a brake valve brake of each vehicle distributor transforms pressure variations of the CG in command of brake cylinder pressure. Finally, brake cylinder (CF) applies the soles on the axles to cause braking effort.

7.6. Breakage of the Coupling

1. When a driver realizes or assumed that his train was divided due to a breakage of the coupling (breakage of a trailer or strike-slip), it causes immediately his train stop. Furthermore, the other agents of the train can be found in the part of the train separated from the spacecraft motor must, as soon as they become aware of the separation through coupling breakage, apply the brakes they have to stop as soon as possible the second part.

2. Any officer who finds a breakage of the coupling must first ensure fast track (or pathways) nearby is not engaged. If this insurance cannot be obtained, for example because of the remoteness of the second part, or if the track (or pathways) nearby is actually engaged, it takes or take protective measures of unexpected obstacles on the track (or channels) interested.

3. After having given, if applicable, the order of the rear protection, the driver proceeded to the visit of the train until the vehicle of rear (see Fig. 6) signalling which he checks (the second part may be divided into several sections). For this visit, it provides the equipment necessary for the replacement of a brake coupling and cover regulatory devices if there are at least two main tracks.

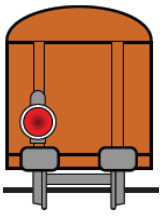

Fig. 6 – Signage indicating the last car of the train.

If it finds a breakage of the coupling, the driver complete, if it is already done, the immobilization of the second part, normally provided by the brake air, squeezing or by tightening a sufficient hand brake.

4. If he thinks possible to remake the hitch, the driver is allowed, if is there nothing, back with caution and not exceed the speed of a man walking to the second part.

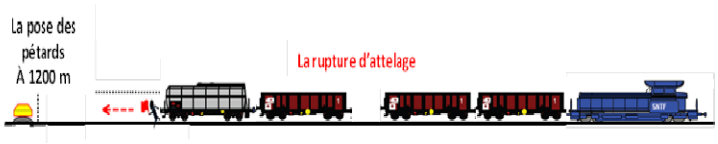

Fig. 7 – Descriptive diagrams of a breakage of the coupling.

7.7. Risks of Breakage of the Coupling

1. Risks related to the Construction of the coupling: (mechanical and tensile strength) in the conditions the most extreme load defined by regulation, hitch uses only 80% of the breaking strength.

2. Risks associated with non-compliance with the safety instructions during operation of the tow bar: all the security officers have been trained good by security experts to manipulate any kind of tension, if they notice during the operation of coupling that there are cracks or defects, they must immediately report the fact to the Chief of service.

3. Risks related to the breach of regulatory material visit: before the expedition of the train set, an officer belonging to the hardware service called 'the visitor', proceeds to a thorough control of the train.

4. Risks linked to the movement of trains (conduct of mechanics): mechanic during the conduct of the train avoids sudden brakes and shocks do not deteriorate tensioners 5. Risks related to the malfunction of the braking system: in cases where the breakage of the coupling will be held, the air circuit which supplies the braking system will be cut. The two parts of the train will be systematically blocked. But if the car has defects of the braking system, especially when it is located at the end of the train, the car will not be blocked, and it comes to himself.

5. Risks related to the breach of regulations for the protection of the trainset in the full process. The tail as soon as he makes the observation of coupling rupture, must:

- apply the brake screw located in the tail.
- immobilize the second parts of the train by approved them available (double calle or drift).
- ensure the protection of his train by the affixing of firecrackers at the prescribed distance (1200 m)

• each car is fitted with a hitch on each side, if the coupler of the opposite car is in good condition, it can use to go up to the first station with a speed limit to delay the car that the tensioner is damaged.
• advise one of the two French stations to report the incident through telephones located in the full process.

8. Method of Analysis: 'Kenny ' Method

Named after its inventor, an American researcher, this method dating back to 1976 is probably one of the best known. It is based on values tables according to gravity, exposure and probability. The following calculation is made: R = E * G * P and the result will be reported in a summary table which will tell whether the risk is acceptable or, on the contrary, if there is place, to the extreme, to cease activities. This method has several advantages as follows:

• it allows to compare different risks in itself little comparable (fall, dislocation, disease);
• it has a certain objectivity provided that same value tables are used every time;
• it allows to quickly classify the risks and to define priorities

Table 1

Values for the frequency of exposure

Frequency of exposure: E	
0.5	Very rare (less than once a year)
1	Rare (annual)
2	Sometimes (monthly)
3	Casual (weekly)
6	Regular (daily)
10	Continuous

Table 2

Values for the gravity

Gravity : G		
1	Small	Injury without loss (damage < €250)
3	Important	Injury with losses (damage between 250 and 2500 €)
7	Serious	Disability, injury irreversible (damage between 25000 and €100000)
15	Very serious	1 death (damage between 25000 and €250000)
40	Catastrophic	Many deaths (damage > 250000 €)

Table 3

Values for the probability

Probability : P	
0.1	Unthinkable
0.2	Virtually impossible
0.5	Thinkable but unlikely
1	Unlikely, but possible in borderline cases
3	Uncommon
6	Quite possible
10	Predictable

Table 4

Risk scores

Risk score: R	
R < or = 20	Very limited risk: acceptable
20 < R < 70	Attention required
70 < R < 200	Measures required
200 < R <ou = 400	Immediate improvement required
R > 400	Activity ceased

9. Examples for Risk Scenarios or Variations

In normal and regulatory conditions equal risk 1 rating is determined by exposure equal 1, severity equal 1 and a probability equals 1. Taking now a few variants for risk exponents during a breakage of the coupling:

Example 1: Imagine that during the formation of a train set of a train, man of team has put cars, the braking system is defective at the end of the train, increasingly it has not respected the limit of loading (the composition of the train is therefore not complying with the regulations and safety is not respected). The train will achieve a line which presents important slopes. The main risk is a risk of breakage of the coupling with a derivative of the cars. The damage feared being the cars that took the derivative with the gradient of the track can reach important speeds, with the mass, cars can easily be derailed at the level of the curves, and can move over hundreds of metres and can cause a disaster. The calculation could be (Table 5): E: regular: 6 - G: disaster 40 or very serious 15 - P: quite possible 6 or downright predictable 10.

Table 5

	Min	Max
E	6	6
G	15	40
P	6	10
Score	540	2400
Measures	Task stopped with survey	Task stopped with survey

Example 2: Suppose that during the formation of an oar from a train, man of team and agent visitor were not well verified witch tensioner was cracked. The main risk is the breakage of the coupling, once the break occurred all security measures have been met. Injury fears it is the disturbance of the circulation of the trains caused by the strong delay (60-120 minutes), prejudice (infringement) to the image of this mode of transport. The calculation could be (Table 6): E: sometimes: 2 - G: 7 serious or very serious 15 - P: little current 3 or all in fact possible 6.

Table 6

	Min	Max
E	2	2
G	7	15
P	3	6
Score	42	180
Measures	Call to order	Blame

Example 3: Imagine that when driving full-developing a sudden shock has caused the breakage of the coupling, the driver stopped the detached portion of the train but it did not provide protection by affixing the firecrackers at the prescribed distance. The main risk is the breakage of the coupling and the collusion of a train on the cars in the full process (catching up). The damage feared alteration of the equipment, serious injuries and even deaths. The calculation could be (Table 7): E: casual: 6 - G: disaster 40 or very serious 15 - P: quite possible 6 or downright predictable 10.

Table 7

	Min	Max
E	3	3
G	15	40
P	6	10
Score	270	1200
Measure	Immediate improvement	Task stopped

10. Conclusions

With qualified and well trained staff, an infrastructure in good condition and reliable installation of equipment high range and sophisticated the SNTF provides its passengers and the transport of their goods safety, gain of time. A priori can be explained this spectacular reaction of prevention by the fact that there inculcate agents on which rests the security they need to be very vigilant to preserve the working tool and ensure the security of goods and persons to honour the company's image.

REFERENCES

Krohmer C., *Collectifs de travail et compétence collective*, *Le cas d'une PME*, 1581-1598. 14 e Congrès AGRH Grenoble, 2003.

Troussier J.-F., *Evolution des collectifs du travail et qualification collective*, Analyses du travail, CEREQ, 115-124, 1990.

Michaux V., *Performance collective et compétences individuelle, collective et organisationnelle: construction d'une grille d'analyse unifiée,* 16ème Conférence de l'AGRH, Paris Dauphine, 2005.

Code UIC 4 2 1, *Règles de composition et de freinage des trains de marchandises en trafic international*, Serrage des attelages dans les trains de marchandises, 6e édition, ISBN 2-7461-0371-0 (version française), 2001.

Règlement générale de la sécurité SNTF. /Edition - 1982

Abdelwahab Aït Razouk, *Gestion stratégique des ressources humaines recherche theorique et empirique sur la durabilité de la relation entre stratégie rh et performance*, Thèse de Doctorat, 2007.

Bailly J.-P., *Comment accroître les performances par un meilleur management* FNEP, 2005.

Code UIC, *Wagon, voiture et fourgon organes de traction normalisation,* 7e édition, ISBN 2-7461-0678-7 (version française), 2003.

Code UIC, *Orientation-compétence et formation pertinentes pour l'encadrement en vue d'améliorer les résultats dans le domaine de la sécurité*,1er édition, ISBN 2-7461-0884-4, 2005.

SECURITATEA CIRCULAȚIEI FEROVIARE. STUDIU DE CAZ: RUPTURA UNEI CUPLE

(Rezumat)

În domeniul căilor ferate, pentru a face ca trenurile să circule în condiţii de siguranţă, este necesar ca o serie de agenţi, cum sunt şeful de departament, personalul care asigură tracţiunea, conductorul, să participe la această misiune. Acești agenți aparţin de patru servicii diferite, dar, în ciuda eterogenității elementelor din grupul în care lucrează în sinergie, au aceeaşi preocupare, respectiv siguranţa pasagerilor şi mărfurilor transportate. Ceea ce încercăm să prezentăm în această lucrare este faptul că siguranţa traficului feroviar se bazează pe o legislaţie destul de "stufoasă" şi că profesia de conductor de tren face parte dintr-o organism bine structurat. Ca urmare, se descrie efectiv activitatea de rutină a fiecărui muncitor, responsabilităţile specifice poziţiei pe care o ocupă şi rolul său în organizaţie. Acesta oferă un mediu favorabil de încredere, de formare şi coordonare.