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Causes of accidents on construction sites: the case of a large construction contractor in Great Britain

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Abstract

In the construction industry in Great Britain, it is estimated that workplace accidents and work-related ill-health cost society £3 billion – this is equivalent to 4% of the construction industry revenue of about £75 billion. Thus, the need to study, understand and effectively manage health and safety (H&S) on construction sites cannot be overemphasised. This paper presents an analysis of accident data recorded by a large construction contractor in Great Britain. The data cover a period of 36 months from April 2004 to March 2007. Pareto analysis was used to determine the relative importance of the causes of accidents on the basis of number of workdays lost. Differences between the four sectors (highways, infrastructure, rail and utilities) in which the company operates were investigated. The case study suggests that the main causes of accidents on construction sites relate to individual attitudes towards H&S. Ability and willingness to implement safe approaches to working and an awareness of their own and others' H&S can contribute to safe performances. It is suggested that the company could increase awareness of H&S issues among the workforce. This should be done on a regular basis through effective training, briefing and debriefing.

Key words

Accidents, large construction contractor, Great Britain

1 Introduction

For individuals directly involved, work place accidents and work related ill-health can lead to any of the following: death, permanent disability, treatment and time off work. For organisations directly involved and society in general, work place accidents and work related ill-health can lead to significant cost. In Great Britain, it was estimated that the cost to society as a whole of work place accidents and work related ill-health in the construction industry was £3 billion (HSE, 2004). This was equivalent to 4% of the construction industry's revenue of about £75 billion. Improving H&S safety performance on construction sites in the Great Britain could lead to significant human and financial gains – it would benefit all parts of society.

In Great Britain, there is a system for reporting events that happen in the work place that have a significant impact on the health and well being of the individuals concerned. This system is governed by the Reporting of Injuries, Diseases and

Dangerous Occurrences Regulations 1995 (RIDDOR 95) which came into force on 1 April 1996. RIDDOR 95 requires any employer, self-employed person or anyone in control of work premises to report any death; injury that requires the injured person to be away from work or unable to do the full range of their normal activities at work; or reportable disease or dangerous occurrence that has not led to any negative consequence but could have (HSE, 2007b). Furthermore, RIDDOR 95 requires employers, employed people or anyone in charge of a work place to keep a record of any reportable event or disease for three years after the date it occurred. The record must include the following: date and method of reporting; date, time and place of event; personal details of those involved; and a brief description of the nature of the event or disease (HSE, 2007b).

This paper presents a case study of a major contracting organisation in Great Britain which runs a number of simultaneous construction sites (work places) all over the country, and is therefore subject to RIDDOR 95. In the interest of anonymity, the organisation will, hereafter, be referred to as Contractor A.

Contractor A is a large construction contractor with over 3400 employees and annual revenue in excess of £400 million. Contractor A's main clients are public sector organisations and regulated private sector organisations. Contractor A delivers services through two primary business segments: maintenance services; and project and engineering services. The maintenance services segment focuses on maintenance of highways and utilities networks through long term partnership and framework contracts (framework contract is a phrase used in the United Kingdom to refer to a contract that establishes terms and conditions under which subsequent contracts will be placed). The engineering and project services segment focuses on enhancement of highways/roads and rail infrastructure as well as waste management, flood protection, ground remediation, foundations, geotechnical engineering and building projects. Contractor A's activities can therefore be seen to fall under four distinct market sectors: highways, rail, utilities and general infrastructure (Begaw, 2007). Contractor A is promoted as a dynamic organisation that is keen to develop and maintain long-term relationships with its customers and supply chain. As of March 2007, Contractor A's forward order book exceeded £1 billion. It also envisaged £400 million worth of contract extensions. It is therefore clear that Contractor A is a significant player in the construction industry in Great Britain.

Like any other organisation in the construction industry, Contractor A can benefit from initiatives to improve H&S on its construction sites. Although Contractor A's H&S performance is quite good – with accident frequency rate of 0.23, placing it in the upper quartile in the construction industry (Begaw, 2007), it has opportunities to improve. Such opportunities can be clarified by analysing the records prepared and kept by the Contractor A under RIDDOR 95. It was for this reason that a study was undertaken to systematically investigate the available data with a view of making suggestions as to how Contractor A could improve H&S on its construction sites, thereby, make savings for itself and society.

2 Research problem

In Great Britain, RIDDOR 95 facilitates the authorities to: identify where and how risks arise; investigate serious events; and provide advice on how to reduce injury, ill health and accidental loss (HSE, 2007b). However, this tends to happen in the context of the entire nation. In order to generate organisation specific solutions, one needs to look at company specific data.

There is need to minimise injuries, diseases and dangerous occurrences on construction sites. When the causes of injuries, diseases and dangerous occurrences are known and understood, one may be able to design procedures and systems which can promote H&S on construction sites.

The aim of the study reported in this paper was therefore twofold: to identify the causes of accidents on company A's construction sites; and to suggest how accidents on Company A's construction sites can be minimised. In order to achieve this aim, the following objectives were pursued:

- Acquire information about incidences of injury, disease or dangerous occurrences;
- Analyse the information acquired in order to identify the primary and secondary causes of the incidences;
- Analyse data derived from the acquired information in order to quantify the relative importance of the primary and secondary causes; and
- Suggest strategies that can lead to reduction in incidences of injury, disease or dangerous occurrences.

3 Methods and results

Incidences of injury, disease or dangerous occurrences

In order to acquire information about incidents of injury, disease or dangerous occurrences, a senior manager in Contractor A responsible for H&S was contacted and requested to provide the information. As there was no interest in personal details of people involved in the incidences, it was easy to demonstrate that no breach of confidentiality or the Data Protection Act could arise. With assurances about confidentiality and data protection, the manager provided the information from records kept by Company A under RIDDOR 95 for the thirty six month period from 1 April 2004 to 31 March 2007.

From the information provided, it was found that 119 reportable accidents (including one fatality) and no diseases or dangerous occurrences had occurred during the period under study. For each of the accidents, the following data were obtained: sector of work, number of days of work lost and brief description of what happened.

Primary and secondary causes of accidents

The description of what happened in each accident was explored using a content analysis approach (Krippendorff, 2004) in order to identify the causes of the accident. By studying the words used to describe what happened in the accident, their meaning and context, the following primary and secondary causes of accidents were identified: casualty error, work method, poor quality kit, poor health, site set up, site conditions, plant operator error, plant failure and packing error.

Casualty error. This category includes all the actions, behaviours, omissions or misjudgements of the person who was injured in the accident. Examples in this category include: accepted poor kit, alpha sleep, carelessness, poor planning, human error, ignorance of wear limits, low self-respect, poor grip, poor observation and unsafe manual handling. Casualty error led to accidents summarised in Tables 1 and 2 below.

Work method. This category includes the procedures and/or techniques employed to execute the activities. Examples in this category include: mini-crane not properly fitted; poor practice – failure to use lifter; poor practice - manual handling; unsafe loading practice; unsecured shoring; and used tow-bar as a step. Work method led to accidents summarised in Table 3 below.

Poor quality kit. This category includes all situations in which defective and/or poorly maintained tools and/or equipment contributed to the accident. Examples in this category include: degraded cable; grinding disc in poor condition; fault with pump starter; grinder not maintained; and poor maintenance. Poor quality kit led to accidents summarised in Table 4 below.

Poor health. This category includes existing health conditions that contributed to the accident. In this category, there was only one case of arthritis that led to a back injury.

Site set up. In this category, all issues relating to how the site was set out and organised are included. There were two cases in which traffic cones were not placed in the right places and injuries occurred as a consequence.

Site conditions. This category includes the physical attributes of the site such as slope, dust and mud as well as the weather conditions such as wind and rain. The category also includes features of the site such as unprotected/unsecured temporary structures. Site conditions led to the accidents described thus:

- Fell through scaffolding ladder access gap and broke collar bone;
- Roping sprayer on back of truck - pulled rope, slipped and twisted knee;
- Walking over bank, slipped and pulled knee ligaments; and
- While lifting a manhole cover, foreign object got in eye.

Plant operator error. This category includes actions, behaviours, omissions or misjudgements of the plant operator. Examples in this category include low safety consciousness, poor judgment and unguarded machinery. Plant operator error led to the accidents described thus:

- 4-inch cut from sanding disc to leg;
- Hit by dumper bruising legs;
- Operative was run over by 3.5 ton dumper, sustained serious injuries;
- Roller rolled back off low loader and broke ankle;
- Run over by roller;
- Runway paving machine hit vehicle and vehicle injured foot;
- Slipped off tow-bar and broke bone while hitching up trailer; and
- Struck from behind by waste moving machine, resulting in severe bruising.

Plant failure. This category includes any type of malfunctioning of any piece of equipment/tool or any part of it. Examples in this category include structural failure and component jam. Plant failure led to the accidents described thus:

- Got thermoplastic from lorry - splashed onto, and injured, arm;
- High pressure hose burst, abdomen punctured; and
- Mobile tower section fell while loading resulting in broken rib.

Packing error. This category includes mistakes made in packing and loading materials and/components before they are brought to the site. Examples in this category include load not stacked properly and components not secured well. Packing error led to accidents described thus:

- Bag of cold tar fell and injured leg; and
- Injured while unlocking steel casings with crane from lorry.

Table 1 Accidents due to casualty error

Bruised hand on boring rods	Climbed down Hiab steps and twisted ankle	Crushed finger between valve & trench	Crushed thumb under ductile iron (DI) pipe
Cut tendon in hand lifting bollard	Cutting lighting column, saw jumped and cut leg	Deep cut to shin due to fall	Disc cutter hit leg
Dropped jackhammer on foot	Dropped road plate onto foot	Dropped wacker plate and pulled back	Exiting mini-digger cab incorrectly
Fell into manhole	Fell on uneven stairs	Forklift pushed sleepers, crushed hand and foot	Getting out of side door van, slipped on step
Hand caught under teleporter forks	Hit 415V cable	Hit by Hiab arm while loading column	Hit cable and suffered burns while using jack hammer
Hit hand while loading concrete	Hit hand while loading fence posts	Hit hand while loading kerbs	Hitting in road pin with sledgehammer, missed and hit index finger
Hurt back lifting blocks from bottom of dumper	Hurt back lifting concrete base sections	Hurt back lifting rubber hose	Injured back lifting riffling sample box
Jackhammer slipped onto foot	Jumped off piling rig and landed on brick	Kicked tarmac into dumper and fell off	Lost tip of finger lowering roll bar
Lost tip of finger whilst drilling	Member of public found dead in excavation	Missed footing and fell 1.5m hitting tracks	Opened guarding on auger and caught finger
Pallet fell forward and hit wrist	Paving slab fell onto foot	Pulled arm placing casings	Pulled back while moving toilet
Pulled wacker plate over foot and broke bones	Released quick hitch and impaled arm	Reversed roller and trapped thumb resulting in fracture	Slipped and fell 15m, while removing scaffolding
Slipped descending ladder, broke foot bone	Slipped off steps of grab lorry, jarred back of the wagon	Slipped on edge of trench / fell on sluice valve	Slipped on previously tipped stone

Table 2 Accidents due to casualty error (continued)

Slipped on road sign, fell and dislocated shoulder	Slipped on rough ground	Slipped on step of lorry, fell causing bruising to shoulder	Slipped on wet ground while getting out of van
Slipped on wet leaves	Slipped pushing wheelbarrow up slope	Slipped while levelling tarmac	Slipped, shin struck a trench sheet
Started vehicle and ran over own leg	Stepped off digger onto uneven ground and broke ankle	Stepped off lorry and turned ankle	Stepped off trailer and broker right ankle
Stepped on shovel and twisted ankle	Stepping out of van and broke a small bone in foot.	Stood awkwardly and twisted ankle	Strained back while using breaker
Strained stomach while lifting hydraulic pack	Struck by pipe-work rolling into excavation	Struck elbow whilst climbing out of excavation	Struck in face by blown off fusion saddle
Subcontractor slipped from the step on dumper	Swabbing wire whipped onto finger	Touched electric cattle fence while using listening stick	Tried to lift trailer alone and injured arm
Tripped on lanyard injuring back	Twisted ankle in Hiab	Twisted back during manual handling	While carrying equipment, slipped and winded self on timber support

Table 4 Accidents due to work method

Back strain whilst lifting trough lids	Boulder rolled into excavation and trapped in pit
Dropped compressor gun catching wedding ring and cut finger to the bone	Dropped manhole cover on foot, broke two bones
Dust in eye	Fell over wall whilst tree clearing, hurt shin/foot
Horizontal shoring slipped and hit head	Jarred back levering hydrant cover
Moving plastic 'T' pieces, felt twinge in back	Pulled back lifting filing trays
Pulled back while levering up manhole lid	Pulled muscle in back while moving a concrete chamber section
Pulled muscles in back while lifting	Slipped in excavation and broke foot while placing barriers
Stepping out of van, slipped off tow-bar jarring lower back	Stone flicked into eye
Took short cut, slipped down bank and twisted ankle	Unloading sheet piles, fell off the back of the wagon

Table 3 Accidents due to poor quality kit

Angle grinder disc broke, grinder jumped and cut knee
Cut hand when lifting
Electrical flash from loose lead on grinder caused burn to wrist
Hit 240V cable in poor repair and was burned
Whilst starting a pressure pump, starting handle kicked back and fractured thumb

Relative importance of the primary and secondary causes of accidents

From the acquired information and subsequent content analysis, a data set including the following variables was derived:

- Sector (measured on a nominal scale: 1 = utilities; 2 = infrastructure; 3 = highways and 4 = rail);
- Primary cause (measured on a nominal scale: 1 = casualty error; 2 = work method; 3 = poor quality kit; 4 = poor health; 5 = site set up; 6 = site conditions; 7 = plant operator error; 8 = plant failure; and 9 = packing (external) error);
- Secondary cause (measured on a nominal scale: 1 = casualty error; 2 = work method; 3 = poor quality kit; 4 = poor health; 5 = site set up; 6 = site conditions; 7 = plant operator error; 8 = plant failure; and 9 = packing error);
- Number of work days lost (measured on a ratio scale: 0 to ∞); and
- Inter-accident time (number of days after previous accident the accident occurred - measured on a ratio scale: 0 to ∞).

In order to identify the relative importance of the primary and secondary causes of accidents, Pareto analysis (Colman and Pulford, 2006) was undertaken for each of the variables with importance measured in terms of 'number of work days lost'. The results from this analysis are illustrated in Figures 1 and 2 below.

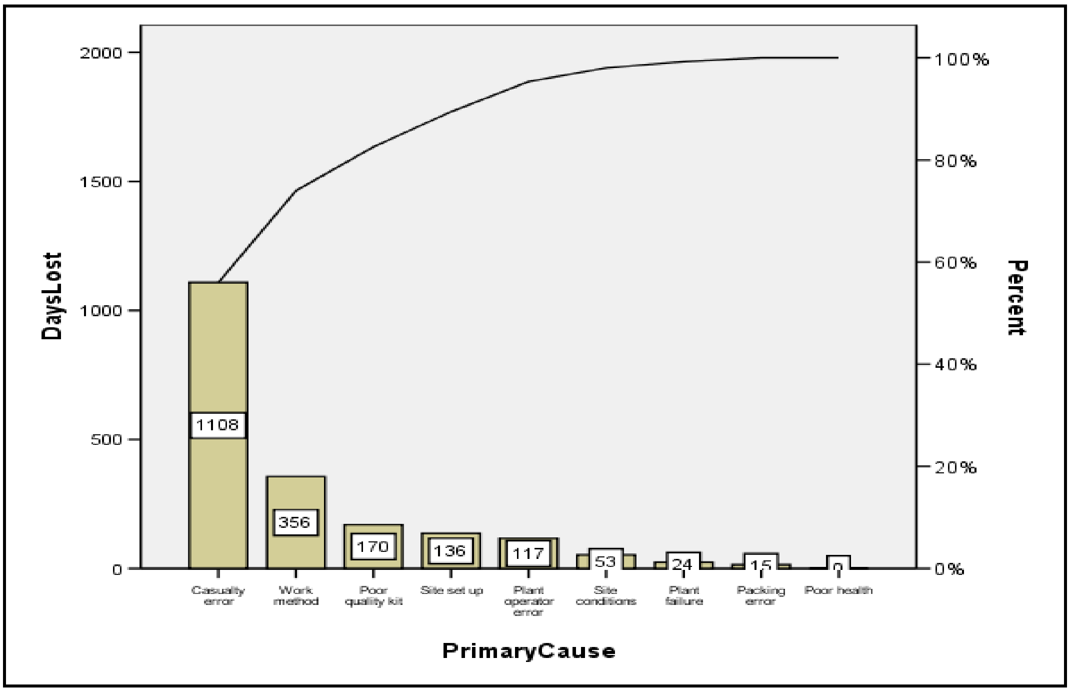

Figure 1 Relative importance of primary cause

Hayden-Elgin (1997) suggests that people tend to be comfortable with things that come in threes – this is a useful idea that can be employed to summarise the relative importance of primary and secondary causes of accidents in this case study. From Figure 1, it can be seen that the top three primary causes of accidents are casualty error, work method and poor quality kit – they account for over 80% of all the work days lost over the study period. From Figure 2, it can be seen that the top three secondary causes of accidents in the case study were work methods, casualty error and site conditions – they account for over 90% of the total work days lost over the study period. It can therefore be said that strategies to reduce accidents on Company A's construction sites that focus on site operatives, how they execute their work, what they use to execute their work and conditions in which they execute their work have potential to drastically improve H&S on the construction sites.

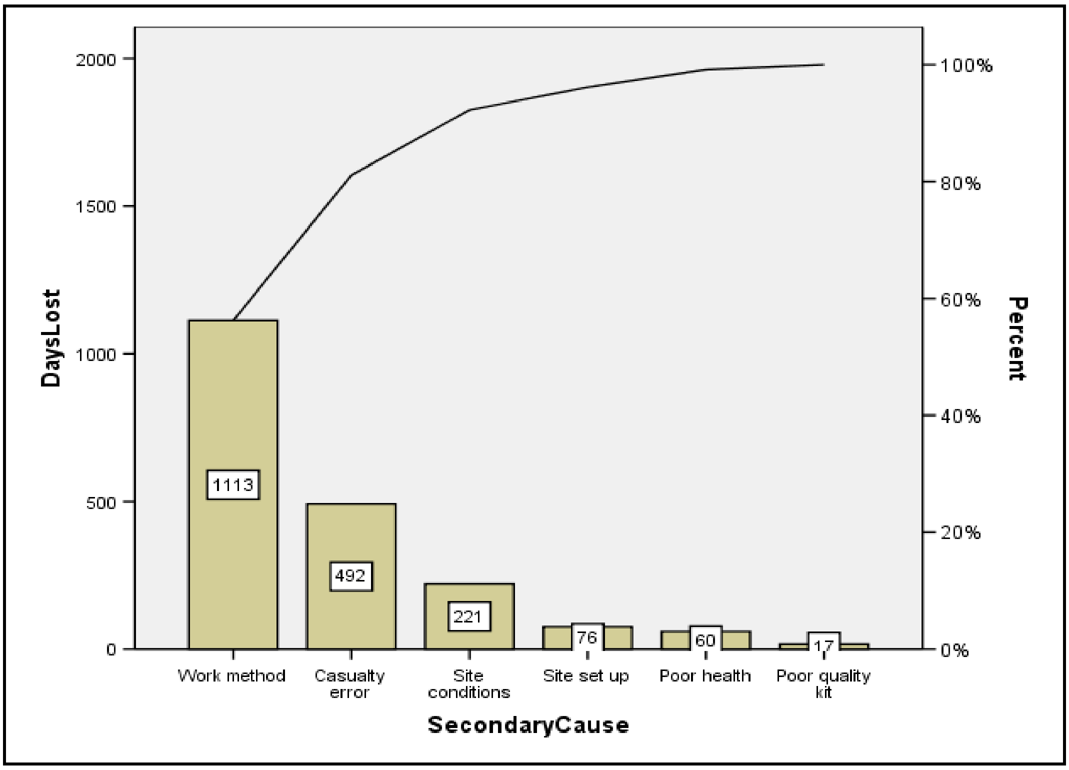

Figure 2 Relative importance of secondary cause

Strategies to reduce accidents

In order to propose strategies for Contractor A to reduce accidents on its construction sites, a detailed analysis of the data was required - this was done by: testing for normality of the inter-accident time and number of work days lost; and testing for differences between the sectors of Contractor A's work. Following the data analysis, mental imagery was employed to develop ideas.

Testing for normality. This was important because the results would lead to the appropriate tests for differences between the sectors. On carrying out the standard normality test, it was established that the inter-accident time and number of work days lost data were non-parametric. Therefore, tests to determine whether there were differences between sectors would have to be non-parametric tests (Coleman and Pulford, 2006).

Testing for differences. This was important because the results would help in establishing whether generic or sector-specific strategies were required. A series of Kruskal Wallis tests (Coleman and Pulford, 2006) were run. The results showed that there were no differences between the sectors as far as inter-accident time and number of work days lost were concerned. This suggests that it would be appropriate to design generic, rather than sector-specific, strategies to reduce accidents on Contractor A's construction sites.

Employing mental imagery. This was important because the causes of accidents were, in the main, related to human behaviour and the behaviour can be understood through quasi-perceptual experiences generated by mental imagery techniques (Thomas, 2007). Details of the issues considered and ideas proposed are presented in section 4 below.

4 Proposal for reducing accidents

Context

The proposal outlined below is based on the following researcher observations about the case study:

- The number of work days lost over the three year period is 1,979. This is equivalent to about 2.5fte positions – even for a large company, this is undesirable.
- The average inter-accident time is 9.28 days (about 3 accidents a month) – accidents are frequent and this is undesirable especially when the impact on individuals, their families and reputation of the construction industry is taken into account.
- The main causes of accidents relate to workforce attitudes towards H&S.
- The workforce's ability and willingness to implement safe approaches to working and awareness of their own and others' H&S can contribute to safer construction sites.

Proposal

It is suggested that Contractor A could increase awareness of H&S issues among the workforce by implementing the framework illustrated in Figure 3 below. The framework builds on the idea that people tend to like things that come in threes (Hayden-Elgin, 1997). The framework consists of three components: training, briefing and debriefing. Each of the components is itself decomposed into three activities. Each activity addresses three criteria. This framework is expected to be effective and preferred.

Training should be aimed at developing individuals who know what to do, how to do it without exposing themselves and others to risk and can help others to acquire similar levels of competence. At macro (organisation/project) level individuals' training needs should be initiated on joining the organisation and/or starting a new project and it should continue throughout the employment/project at a pace commensurate to organisational and individuals' needs. At micro (project phase/activity) level, individuals should be trained as project activities/phases advance and new skills/competences are required.

Briefing should be aimed at reminding individuals of what to do and what it takes to do it safely. It should be carried out on a daily basis at the beginning of the project activity for a few days. Thereafter, it could be carried out less frequently, but regularly, until the activity is completed.

Debriefing should be aimed at highlighting lessons to be learnt and reinforcing knowledge already acquired to facilitate the development of H&S awareness as an integral aspect of people's work practice. Like briefing, debriefing should be frequent at the beginning of project activities and less frequent, but regular, thereafter.

Training
- Initial training - to gain technical skills, health and safety awareness and professional values;
- Advanced training - to master technical skills, deepen health and safety knowledge and develop leadership skills;
- Periodic training - to value human life, understand human behaviour and communicate effectively.

Briefing
- Unpack tools/equipment - to ensure they are right, sufficient and safe;
- Prepare for work - rehearse processes, answer any questions and check understanding; and
- Discuss risks - identify risks, explain warning signs for the risks and highlight how the risk exposure can be minimised.

Debriefing
- Pack up tools/equipment - check, clean and recharge them;
- Reflect on what happened - identify risk events that occurred, explain why the risk events occurred and identify the impact of the events; and
- Reflect on what did not happen - identify risk events that were avoided, why the risks events were avoided and what needs to be done next time.

Figure 3 Framework for increasing H&S awareness

5 Conclusions

From the work undertaken in the case study, the authors can draw the following conclusions:

- It is important that H&S is taken seriously at all levels in the construction industry as it affects all of us either directly or indirectly;
- The causes of accidents on Contractor A's sites are: casualty error, poor quality kit, work method, poor health, site set up, site conditions, plant operator error, plant failure and packing error;
- The top three primary causes of accidents on Contractor A's sites are casualty error, work method and poor quality kit while the top three secondary causes are work methods, casualty error and site conditions;
- Action that focuses on effective training, briefing and debriefing of workforce can increase awareness of H&S issues among the workforce and lead to reduction in accidents on construction sites; and
- This case study provides useful lessons for Contractor A and other contractors in Great Britain and possibly other countries.

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