

THE HUMAN ELEMENT COMPETENCY REQUIRED FOR DESIGN APPRAISAL

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SUMMARY

One way for the human element to make an impact on a large scale is through inclusion of ergonomic requirements in Class Rules. This can be achieved by two means; by introducing specific human element requirements into the Rules and by making current rule requirements with human element implications more explicit. However, for surveyors who assure Rule compliance, their knowledge or awareness of the human element is often poor or indeed absent. Any attempt to address the human element in the Rules requires that the competence of surveyors is increased at the same time as the Rules are revised. Raising awareness of the subject is an essential first step if the benefits of improved design are to be realised. This paper outlines how Lloyd's Register is striving to address the human element in the Rules whilst at the same time putting in place mechanisms to ensure surveyor competency is met. The paper discusses the development of internal human element awareness training, the first step towards achieving a competent workforce in this area.

NOMENCLATURE

ECL	Ergonomic Container Lashing (notation)
GBS	Goal Based Standards
HEWG	Human Element Working Group
IEC	International Electrotechnical Commission
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
LR	Lloyd's Register
MLC	Maritime Labour Convention
MSD	Musculo-Skeletal Disorders
OSH	Occupational Health and Safety
TC	Technical Committee

Classification Rules and Regulations and Type Approval are the main means of mitigating error in the design and construction of ships and their components. Hence, the inclusion of Human Element requirements in the Class Rules and Regulations is one way to make a credible impact on a large scale. Class provides a means, with corresponding verification, to make far-reaching improvements benefiting a large numbers of seafarers.

Addressing the human element both in the Rules and in supporting consultancy services is an activity that is strongly supported by senior staff in Lloyd's Register (LR) and by its Technical Committee. Addressing the human element in the Rules is however a challenging activity and one which has no quick win solution. The process from concept through to approval of Rule requirements is lengthy, and one where many hurdles present themselves. This includes gaining acceptance from both internal and external stakeholders. Internal stakeholders such as surveyors need clear verifiable requirements and mechanisms need to be put in place to ensure they are able to competently verify ergonomic Rule requirements. External stakeholders such as shipyards are also critical, as they are often the body who chooses the Classification Society. If Rule requirements are too complex it will increase the cost of build and this will be unappealing to the yards.

This paper will explore the testing nature of writing ergonomic Rule requirements and the issues regarding competency of surveyors who provide assurance of the Rules.

1. INTRODUCTION

There is a growing awareness in the marine industry that the human element needs to be considered in ship design if seafarers are to operate a ship and its systems safely and effectively. The traditional view which sees human error as the individual responsibility of the officers and the crew is simplistic and needs to change. There needs to be a move to recognise the root cause of error which can often be traced back to the design and build stage in a ship's lifecycle. These early stages of a ship's lifecycle present effective and practical opportunities for mitigating some of the risks which the ship and its crew would otherwise face when it enters into service.

The operational context onboard ship's has changed and there is evidence to suggest that these separate developments may not be compatible. The seafarer population is changing in terms of skills and competency. Crew manning levels are reducing. The ship, its systems and its equipment is becoming increasingly automated, integrated and complex. Special consideration thus needs to be made regarding usability and operability. There is a danger that if this is not addressed, there will be major repercussions for the industry.

2. CHALLENGES OF APPLYING ERGONOMICS TO DESIGN

There are several problems that have contributed to the challenges faced by ergonomists when it comes to safe ship design. A principal challenge is that ergonomic design for seafarers is largely not considered in the marine environment. Although this is slowly changing, the marine industry still needs to take considerable steps if it is to catch up with other high hazard industries such

as rail and aviation which have been proactive in ergonomic design for many years.

An early challenge will be in educating designers and other stakeholders of the benefits of ergonomics in design. The reason why the industry still lags behind is due to a distinct lack of knowledge among designers of ships and their systems. Naval architects generally receive little or no training in Occupational Safety and Health (OSH) or work system design. The same can also be said for Class Surveyors. In general, operational design comes some way behind the classic 3 S's that dominate ship design, i.e. speed, strength and stability.

In March 2010, after several years of development, LR launched its first ergonomic themed Rules notation – Ergonomic Container Lashing (ECL). The notation is currently optional but may become mandatory in time. The intention of the optional notation is to improve the safety of working arrangements for port workers and the ship's crew when performing container securing, inspection and other related tasks. The problems faced in developing, gaining approval, and achieving buy in for the notation from surveyors are noteworthy. In critiquing the work undertaken for ECL, several challenges for the rules ergonomist emerged [1]. Many of the challenges could be considered relevant for applying ergonomics in ship design generally.

In order to understand the challenges faced, a brief synopsis of the problems with current container ship design is useful. Container securing carried out by port workers is one of the most dangerous and physically demanding jobs in the shipping industry. The main hazards are falls from height, falls on the level, slips, trips and musculoskeletal disorders (MSDs) [2]. There are several working positions onboard where such hazards are prevalent, these include; working on hatch cover ends, working on outboard positions, working on lashing bridges and working between container stacks on hatch covers. The design of container ships is a challenging high pace activity, where structural strength, ship dynamics, carrying capacity and other factors interact. In general, the main pressure on ship designers is to ensure that the container stacks do not impair ship safety, and that the containers are safely stowed. The role of the port worker is generally not considered.

At the outset, addressing the design shortcomings to create a safe and operable working environment for port workers, appeared to be a relatively straightforward task. The type of design requirements to address many of the hazards could be described as relatively low cost, simple measures. However the process of developing criteria that were ergonomically sound and technically clear, assessable and acceptable to all stakeholders including surveyors was not without numerous challenges and proved to be an immense learning curve for the Rules Ergonomist. It is not unexpected that ergonomic requirements proposed for inclusion in the Rules are

rigorously scrutinised by surveyors, as verification of Class Rules will be their responsibility.

An essential element of developing criteria for ECL was to gain approval and acceptance from surveyors. A principal intention of the notation was that it be applied and understood by surveyors with minimal support. Both plan approval surveyors and field surveyors require well written explicit rules. For the plan approval surveyor, each applicable rule has to be checked against the ship's plans without any ambiguity. The field surveyor will be required to check those aspects of the rules that can't be verified from plans.

Even though the criteria in ECL are fairly straightforward the novelty of an ergonomic themed notation was met with resistance where, in the opinion of the surveyors, the requirements were unverifiable and assessment of compliance was not straightforward. Surveyors make judgements about engineering, but not human behaviour. They are not trained to make ergonomic judgements, thus some of the proposed requirements in the notation that were not structurally defined and could not be verified on plans had to be re-evaluated. For any ergonomic requirements to be accepted, a Rules ergonomist learns quickly that it is essential that any criteria are defensible and they are of scientific merit.

A further novel feature for surveyors in the notation and one which could be applicable to many ergonomic design scenarios onboard is the mitigation of occupational health hazards. As stated earlier, the prevalence of MSDs among port workers is a problem. Requirements in the notation relating to occupational health often required more justification to surveyors and designers possibly because OSH is unfamiliar to them.

3. LR STRATEGY FOR RULES DEVELOPMENT

A key part of the LR strategy for the human element is to improve the way it is addressed in the Class Rules. The principle that Class Rules should address the human element comes from a decision of the LR Technical Committee (TC) in 2007 and the theme of seafarer safety comes from the extension of the LR mission statement to emphasise safety and environment.

It is imperative that the strategic direction for human element rules development is justifiable with clear benefits if it is to be supported by the Marine Technical Director and the TC. In order to develop the technical scope of the strategy, the themes and human element priority areas identified by the IMO Human Element Working Group and the Goal Based Standards Working Group have been examined. The strategy has also been determined from the ILO Maritime Labour Convention (MLC) and other industry initiatives such as the Alert project. This examination has helped determine the

forthcoming plan of work for addressing human element in the Class Rules.

The IMO made a statement in a 2003 Resolution, 'Human Element Vision, Principles and Goals for the Organization vision' [3]. While the Resolution was devised to direct the work of IMO itself, it lays out an approach that the human element should be addressed by the wider marine industry. It acknowledges that '(the human element) involves the entire spectrum of human activities performed by ships' crews, shore based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to cooperate to address human element issues effectively'.

IMO's Human Element Working Group (HEWG), which has up until now been convened at periodic sessions of the Maritime Safety Committee and the Marine Environment Protection Committee, considers design as well as operational matters. The HEWG has issued Circulars to facilitate action. A 'Checklist for Considering Human Element Issues by IMO Bodies' [4] includes working environment and human factors engineering criteria. In its 'Framework for Consideration of Ergonomics and Work Environment' [5] it specifies areas in which the efforts of IMO should be strengthened in this regard. The identified design areas have a strong link with Rules development. Included among the criteria are stairs, vertical ladders, walkways and work platforms and aspects of the working environment such as layout of spaces, noise, climate and vibration.

The Human Element is further addressed by IMO's Goal Based Standards (GBS). MSC 296(87) stipulates 'that the rules incorporate human element and ergonomic considerations into the structural design and arrangement to facilitate operations, inspection and maintenance activity' [6]. The priority areas closely align with those raised by the HEWG and these will become part of our statutory programme of work in Rules development.

The forthcoming implementation of the ILO MLC [7] will also have implications for the Rules development strategy. In addition to operational elements, the Convention also stipulates some design recommendations, for example, crew accommodation, washroom facilities, lighting, noise and temperature levels.

Another indication of what needs to be addressed comes from the publication Alert! – The International Maritime Human Element Bulletin [8]. Alert! is a Nautical Institute project, sponsored by the Lloyd's Register Educational Trust, which has been hugely successful in improving awareness of the human element in the marine industry over the last number of years. Series 2 assembled a list of top issues to be tackled as a priority. Included in the list was addressing slips, trips and falls and automation and

alarm management, both of which are strongly rule related.

Analysis of these themes and priorities has helped develop a strategy for implementing the human element in the Rules and has helped identify our programme of work. Some Human Element themes relate to short or long term harm to seafarers and will be addressed in part through statutory instruments. Their inclusion in the Rules will be determined by the schedule of the relevant instrument. The Rules will detail the design requirements to meet the statutory targets. These issues will include;

- Environmental targets (noise, vibration, lighting, indoor climate, toxicity)
- MLC topics in particular accommodation and thermal injury

Other themes in the GBS and HEWG strategy are intended to be progressed entirely by Class. These are;

- Slips, trips and falls
- Access / egress

The intention is that slips, trips and falls will be the next area of Rules development due to commence in 2012. Slips, trips and falls are the leading cause of seafarer injuries onboard commercial vessels and improving design to reduce risks meets what industry stakeholders need and expect.

There will be three stages to each piece of development work: Research, Development and Approval (of proposal). Each stage will take approximately a year elapsed time. This time estimate has been based on our current rule development work. Much of the required time will be taken up in consultation with stakeholders and waiting for feedback.

Rules development work for 2011 has seen proposed requirements for ergonomic design of control stations. At the time of writing this paper, the rules proposal is awaiting approval from the TC due in late October. This Rule proposal is discussed in more detail in the next section of the paper.

4. RULES DEVELOPMENT

4.1 THE STORY SO FAR

The development of ergonomic requirements is not a totally new concept to LR. The importance of this discipline has been recognised in the development of human element rule requirements for key elements in other LR optional notations, for example Navigational Arrangements (NAV1), Integrated Bridge Systems (IBS) and Passenger and Crew Accommodation Comfort (PCAC). Also, as mentioned earlier the first pure ergonomic themed optional notation ECL was launched in 2010. In development at present is another pure

ergonomic optional notation for the offshore support vessel (OSV) bridge. This notation will be called Ship Control Centre (SCC) when launched.

As a result of the aforementioned 2007 TC request to address human element in the Rules, the current focus has moved onto developing mandatory requirements in our core Rules. There are two possible means of addressing human element in these Rules. It can be achieved by introducing specific human element requirements into the Rules or by making current rule requirements with human element implications more explicit.

In 2003, LR initiated a project to find out what the society already said in its Rules with regard to the Human Element [9]. The study found over 1000 requirements that had implicit human element requirements. The findings from this project reinforced the importance of addressing surveyor competency. If surveyors are not educated in the human element it is likely that they are not making inferences regarding human behaviour in any of these implicit requirements.

There are some striking differences between having mandatory requirements in the core Rules and requirements in optional class notations. Some immediate differences include the fact that any mandatory requirements will be applicable to all ships and not to just those who have opted for it. As such, a balance must be struck that allows a best practice approach but one that is realistically going to be implemented on all vessels. If ergonomic requirements are not pragmatic and are too sweeping, they will not be accepted and the time taken during the development stage will have been poorly spent. Further, there is going to be an inevitable increase in human element competency required by surveyors worldwide when ergonomic requirements become part of the mandatory class rules. As such, need for a human element surveyor authorisation becomes paramount. This will be discussed in the next section of the paper

4.2. CURRENT RULES DEVELOPMENT

In 2010, the first rule proposal was submitted for approval to the TC as a result of their 2007 request. The changes proposed related to the Electrical Engineering Rules and are intended to contribute to improving the safety of electrical installations on ships, represent good practice and to be practical to implement. The proposal was kept purposely short in scope in order to assess receptiveness of the TC. The proposed requirements which both introduced some new requirements and also made some current requirements more explicit were approved.

This year has seen a far more comprehensive and ambitious proposal being put forward for approval that addresses the human element in the control engineering

Rules. Around two years have elapsed, since inception of the request to do the work, to the current stage where imminent approval is awaited. The development of sensible requirements for control stations can be described as being relatively straightforward. The challenge has been in making them pragmatic, verifiable and acceptable to all stakeholders. These requirements will become applicable to all LR Classed vessels, so they need to be thoroughly researched, developed and be of good quality ergonomics.

The existing control engineering Rules already have some intentional human element requirements. However, surveyor feedback indicates that the full intent of some of these requirements is not always fully understood and their intended benefits are thus not necessarily achieved. The scope, of these same requirements, doesn't include all elements of the control work space. There are for instance, no requirements relating to either the physical work environment or the physical layout of control stations in the present requirements. The current Rules proposal therefore intends to address both the explicitness and scope of the current human element requirements.

This ergonomic Rule proposal is more ambitious as we are seeking for it to have its own section within the Control Engineering Rules Chapter. This section would be sub-divided covering physical layout of control stations, the physical operator working environment, the operator interface, controls and displays. The overall goal of this proposed set of requirements is to enhance operational performance, reduce risks to safety and to reduce the likelihood of human error.

The Rule proposal has been developed using a combination of International Standards. There are no specific IMO, ISO or IEC marine standards for ship control rooms per se, so a range of standards specific for bridge design, engine room design and general control room design have been applied. The proposal attempts to bring control station design to a standard comparable to the bridge by taking the applicable good design principles from the bridge standards and transferring them to control station design.

5. SURVEYOR COMPETENCY REQUIREMENTS

As ergonomic Rule requirements increase, the competency of surveyors needs to increase at the same time. The verification of any ergonomic requirements in the Rules will be undertaken by surveyors. LR is not intending to employ large numbers of ergonomists in place of surveyors to assure ergonomic requirements. However, there may be special cases, for example the SCC notation (when launched), which may require ergonomists to provide assistance to plan approval surveyors. This is because the notation has some very

complex ergonomic requirements that would be outside surveyor remit.

Surveyors provide feedback during the course of the rule development process. In order that they provide valuable feedback and also engage, with what is intended to be achieved, they need to have competency in the human element.

As discussed earlier, surveyors are trained to make decisions about engineering not human behaviour. Therefore, the need to have a Human Element Competency framework for surveyors is equally as important as any new human element Rule requirements themselves. Similar to Rules development, a programme of work has been developed to meet this need.

In order to develop an appropriate training programme a Training Needs Analysis (TNA) was conducted in the first instance.

5.1 TRAINING NEEDS ANALYSIS

It is normal when doing a Training Needs Analysis to have user tasks pre-defined. Here, however, the analysis is proceeding on the basis of material to be learned. Therefore, we need to define tasks before we can identify the training gap in terms of knowledge, skills and attitudes (KSA) and then work out training delivery. To some extent, the tasks and the KSA are being developed together in this analysis.

5.1 (a) Surveyor Tasks to incorporate operational design

There are some surveyor tasks that would have an indirect affect on operational design. Approving workshop practice, for example welding, is an example of that. The bulk of the surveyor's tasks, however, can have a significant and direct impact on operational design. The tasks to be considered are:

- Plan approval (hull and structure, machinery, controls and systems)
- Initial survey, sea trials
- Periodic surveys
- ISM audits
- Regulatory survey

5.1 (b) Knowledge, Skills and Attitudes

If surveyors are to be expected to verify human element requirements in the Rules, we need to ensure they are provided with baseline knowledge of the subject. They will first and foremost need to gain an understanding as to what the human element is and be persuaded of its importance in the marine industry and in their day to day duties. Surveyors will need to know some material – or at least enough to know where to find material - and when to seek assistance with non-routine matters.

The craft skills to be developed for the application of the human element to Rules include being able to conduct an informal context of use analysis and to identify critical factors in the range of contexts that may be encountered, for example language differences.

The attitude that needs to be developed among surveyors is one where they begin to think about operability as similar to other aspects of safety. There may be areas where poor usability is irrelevant, and this needs to be acknowledged but the prevalence of areas where it is an error-producing condition needs to be appreciated.

5.2 TRAINING DELIVERY PROPOSALS

In the first instance, there will be a human element awareness raising course developed. This course will be fairly basic in scope, as it needs to lay the foundations for education in this subject. The intention is that this course will be completed by all marine surveyors. To address the findings of the KSA analysis the course will cover the following topics:

- The benefits of addressing the human element
- The relevance of the human element in design, build and operation in a rapidly changing marine environment (new technology, changing seafarer population)
- Regulatory expectations with respect to the human element
- The people aspects of system design (both the effect of (Occupational Health and Safety) and affect of people ('human error') with respect to hazards)
- Context of Use analysis for design evaluation of Human Element issues
- Information on where to access human element material

Further training needs will be met as the Rules develop in specific areas. Specific topic areas are required for the different types of survey task. For example, the control station Rules, expected to be approved in November 2011, will require specific training and guidance for electrotechnical surveyors. Both a guidance document will be developed to support these new Rule requirements and training will be developed tailored to the needs of surveyors assuring these requirements.

The competence of surveyors performing statutory surveys to apply the increasing number of human element regulations also needs to be addressed.

5.3 TRAINING DESIGN

The human element awareness raising course will need to be completed by all marine staff who work in: field survey, plan approval survey, statutory survey or design support for new construction or existing ships. In order to reach such a global community, it has been decided that

the training will be provided through e-learning accompanied by an online assessment. E-Learning is a widely used training method adopted by LR and has been considered the most practical approach to take for this course.

The course is currently in the process of being developed. At the time of writing this paper, the draft storyboard had been devised and work is due to commence with a third party training company shortly. The intended roll out of the course will be the first quarter of 2012.

5.4 IMPLEMENTING TRAINING

Implementing a training course particularly on a novel subject brings a range of challenges. However, the human element is now part of the LR Surveyor Competency Framework. This has added considerable weight to the training course as it will assist with its take up. As part of the competency scheme, it will become a prerequisite for all surveyors to undertake the training. Successful completion of the training course and assessment will become the means to assess the surveyor competency in human element.

The success of the course will be measured by the number of queries received from surveyors. We do not expect surveyors to make expertise-based human element decisions but we do hope that they will be able to recognise human element issues and will seek assistance from a human element specialist when required.

As the Rules develop in the different engineering areas, and specific training is developed, these training courses will become part of the competency schemes within the specialised domains.

6. CONCLUSIONS

The need to address the human element in design is essential if seafarers are to be able to operate a modern ship and its systems safely and effectively. Class Rules and Regulations are the main means of mitigating human error in the design and construction of ships and their components. Hence, the inclusion of human element requirements in the Rules is one way of making a credible impact on a large scale.

Rule development is a challenging activity. The process is lengthy with no quick win solution. There are internal and external stakeholders who bring a diverse range of needs that have to be addressed. There is also a considerable amount of persuading that needs to be done in order to gain buy-in.

In developing good quality ergonomic rules, it is essential that they are verifiable and pragmatic. They need to be in a language that is understood by non-

ergonomists and for which compliance assessment is straightforward.

The competency of surveyors needs to improve at the same time as rules develop. Surveyor competency in the human element becomes essentially as important as any new rule requirements, as they will be the group who provide assurance that the Rules are satisfied. This is a huge task that can only be achieved through awareness raising (such as Alert!) and training.

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