Safety and Environmental compliance impacts to physical assets maintenance

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Abstract

The advent of safety and environmental legislation in many countries have constrained the way manufacturing equipment is maintained. The lack of compliance to the safety and environmental legislative requirements has resulted in some manufacturing equipment being unavailable for service until the requirements were met. A study was undertaken to reveal the typical legislative safety and environmental requirements that are applicable to a manufacturing organization. The impact that is resultant to the manufacturing assets' lack of compliance to legislative requirements was assessed to verify the effect on equipment availability and, therefore the on the overall production throughput.

Keywords

Safety compliance; environmental compliance; asset availability; impact; legislative requirements

1. Introduction

All the relevant maintenance standards for safety and environmental compliant physical assets must incorporate all the relevant standards, and consequently, a vigorous quality assurance verification system has to be assimilated (Aldairi et al., 2017:109). Notwithstanding many businesses increasingly embracing sustainable performance into their fold and being propelled by government legislative incentives and policies, a majority of firms still are pursuing their own business objectives that are centred on the economic norms (profitability, throughput, market performance...) (Sénéchal, 2016:85). Businesses have to focus on all three elements of sustainable operations management altogether, which are also in line with the Triple-Bottom-Line (TBL) concept and its three(3) proportions of the economical, environmental, and social factors (Pires et al., 2016:150) (Sénéchal, 2016:85) (Lim and Biswas, 2018:540). Recently, there has been an evolution of the likes of sustainable maintenance, which is a novel challenge for industries to trail sustainable development initiatives in their maintenance deployment (Amrina and Yulianto, 2018:012055). Some research based results have revealed that in terms of sustainable maintenance, the economic dynamic is viewed as the elementary factor, the social dynamic as the intermediary factor, while the environmental dynamic is designated to be the foremost factor (Amrina and Yulianto, 2018:012055).
Unless amalgamation between "Green Maintenance" and sustainable maintenance is enhanced, much of the environmental monuments will be destroyed and the future generations may be unable to find the much valued historic environments (Kayan, 2015:25). Many maintenance practitioners globally have to repair structurally damaged support structures subjected to corrosion, and the maintenance actions should guarantee optimum levels of

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reliability and safety, at the same time minimizing costs and environmental impacts (Bastidas-Arteaga and Schoefs, 2015:162).

2. A Move towards sustainable development and maintenance

Sustainability is defined in diverse ways dependent on its systematic application, but the basic is generally focussed on the integration of the manifold intentions of economic advance, social advancement and ecological stability (Shi et al., 2013:104). According to the World Commission on Environment and Development (1987), sustainable development is defined as that "development that satisfies the necessities of the existing populace without eliminating the capability of forthcoming generations to satisfy their own necessities" (Shi et al., 2013:104). Sustainability has been rated as a highly critical aspect in some industries such as the automotive industry (Sari et al., 2015:443). The depleting and scarce natural resources coupled with the reinforcement of punitive safety and environmental regulations have compelled organizations to take sustainability initiatives seriously (Sari et al., 2015:443). This has culminated in the move to embrace sustainability as of paramount significance by a wide variety of industries (Shi et al., 2013:104). Sustainable development has become a domineering principle for our present industrial society (Sodangi et al., 2014:11). The move toward sustainable operations have borne three prominent areas of green manufacturing and process developments, lean and green operations and the circular economic cycle (Shi et al., 2013:104). In countries like the USA, the environmental aspects pertaining to the water and air quality, and wildlife are regulated as per the Clean Water Act, Clean Air Act, and Federal Endangered Species Act (Shi et al., 2013:105).

3. Moving towards safety and environmental focused maintenance

Safety and environmental compliance issues have compelled some North American maintenance departments to make changes to their maintenance practices to circumvent activities that impact on people's health or the environmental wellbeing, such as transitioning from using abrasives to the use of chemicals for winter road maintenance (Shi et al., 2013:105). This was necessitated by the negative effect of abrasives (e.g., sand) to water-quality and aquatic-species, air-quality, plant life, and soil, and the additional costs of cleaning the sand (Shi et al., 2013:105). Additionally, the application of abrasive material for the winter maintenance had costs and environmental repercussions as valuable resources were depleted, and air pollution which could harm people's lungs was generated (Shi et al., 2013:105).

The critical aspect of safety and prolonged existence of engineering equipment is of growing significance because of their adverse effects in the event of disastrous failures occurring (Novak et al., 2017:67). Safety consequences are a concern for every enterprise, and more so to those involved with critical infrastructure like roads, dams and power transmission grids (Novak et al., 2017:67). Steam boilers have also come under crucial safety monitoring due to their disastrous consequences in the event of catastrophic failures. Any breach of safety protocols within the critical infrastructural domain may result in failures that affect service delivery to the society, and can impact on their health and safety and in some instances impacting adversely on the natural habitat over the long term, e.g. fires, sewerage contamination, etc. (Novak et al., 2017:67). It is therefore imperative that organizations have put in place measures that ensure that critical equipment and/or infrastructure are maintained in such a way that failures with adverse effects to the society and environment at large are prevented (Novak et al., 2017:67). The maintenance may include inspections and prescribe scheduled repairs that minimize the impacts of safety fissures and this also entail safety organisational turnaround with embedded safety/environmental cultural practices (Novak et al., 2017:67). The impact of some failures especially on national infrastructure like the electrical power grid, can transcend geographical boundaries and economic sectors, and this is why maintenance goals for such critical assets need to be derived with the society and environment in mind (Novak et al., 2017:68).

For the infrastructures like the ports and bridges, structural safety is of supreme prominence during their entire lifetimes (Zhang et al., 2017:1693). Destructive factors such as strong winds and corrosive agents can compromise structural integrity and cause degradation alike, calling for the timely maintenance to guarantee safe operation of the infrastructure or assets. Insufficient maintenance has adverse effects on the safe operation of infrastructure such as boilers, goods and passenger lifts, bridges, etc. and can have colossal adverse impact on the society/environment (Zhang et al., 2017:1694).

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Generally, structural maintenance is planned in such a way that a full structural performance assessment is done, with the following aspects covered: Inspection covering prevailing status of asset/infrastructure; estimation of the remaining useful/service life of asset/infrastructure and prediction of prospective performance of degraded structures/components; quantification of the costs of maintenance inclusive of economic, environmental and societal reflexions; and the assessment of effective maintenance strategies and identification of optimal solutions as per the target factor (Zhang et al., 2017:1695). Below is a display of the impact of planned maintenance actions on the health index of a safety critical asset.

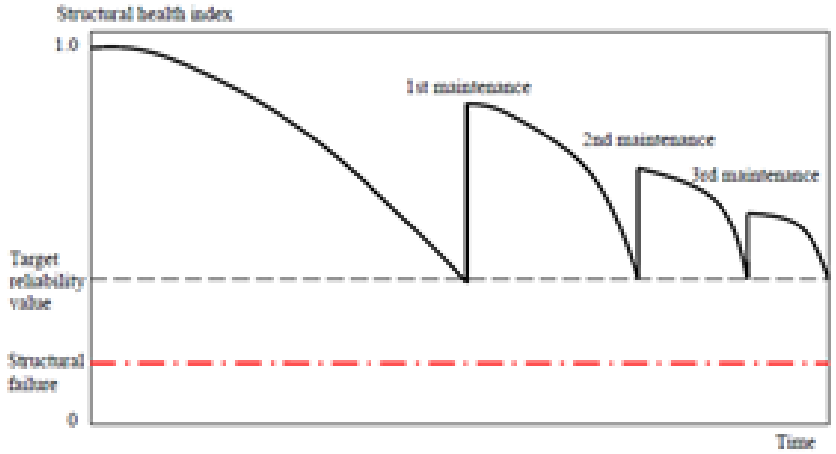

Fig. 1: Safety Health and Environmental based maintenance planning and actions (Zhang et al., 2017:1697)

Some assets like aircrafts have a considerable impacts with regards to atmospheric emissions as they primarily emit primarily CO2, CO, H2O, HC, NOx and SOx (Carou et al., 2017:465). Motor vehicles are also notorious for atmospheric emissions along with some processing industries, and a raft of legislative requirements have been put in place by various local authorities to curb atmospheric pollution through the application of restrictive emission levels (Carou et al., 2017:465). In addition to pollution controls for aircrafts, the structural integrity of an aircraft is a major safety concern as under normal operations, the structures are exposed to stress corrosion cracking, fatigue and wear, thereby demanding a high level maintenance regime to prevent catastrophic operational failures (Carou et al., 2017:465). For a lack of effective repairs and maintenance system, entire structural breakdown or localized failures may occur in steel bridges, e.g. the 1994 Seongsu Bridge in Korea disaster when the steel bridge collapsed (Wang et al., 2017:53). See picture below.

Fig.2: Collapsed Steel bridge - Seongsu Bridge, Korea, 1994 (Wang et al., 2017:51).

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The issues such as fatigue cracking, if they go unchecked in a steel structure can cause disastrous consequences such as the bridge collapse that was shown above. Measures have to be put in place to ensure that infrastructure and assets are maintained for safety, otherwise their failure may entail long unavailability for the assets to the society to use. The figure below shows a fatigue crack on a welded joint.

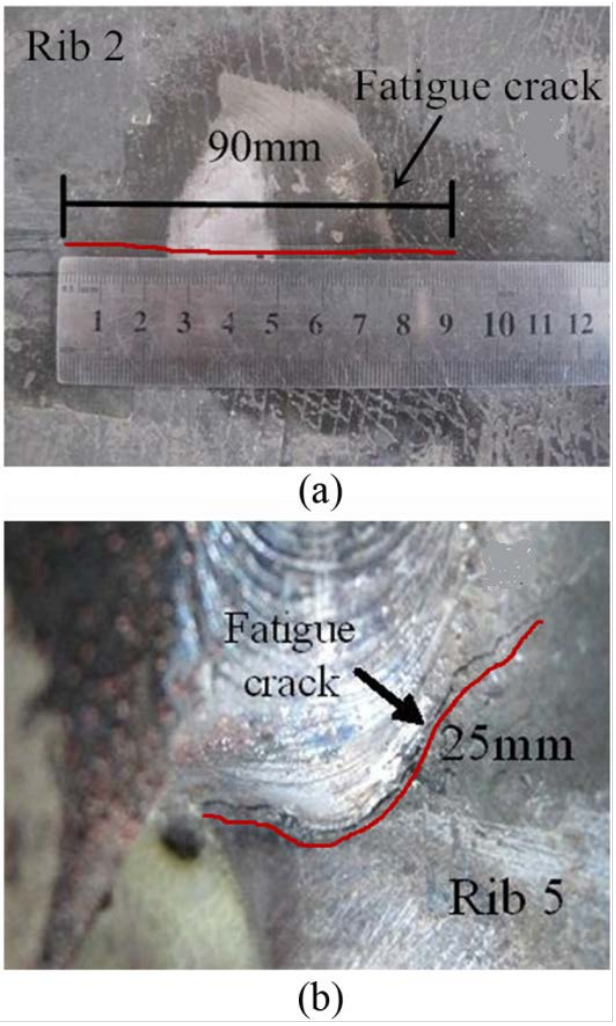

Fig. 3: Fatigue cracking: (a) on welded joint no. 1 and (b) welded joint no. 2 (Wang et al., 2017:54).

Maintenance these days should account the systems accidents and disasters occurrence risks, on top of focussing on cost-effectiveness and technological advancements (Papic et al, 2009:534). The maintenance system should ensure that safety aspects are fully embedded in the set targets for any maintenance system as displayed in the figure below.

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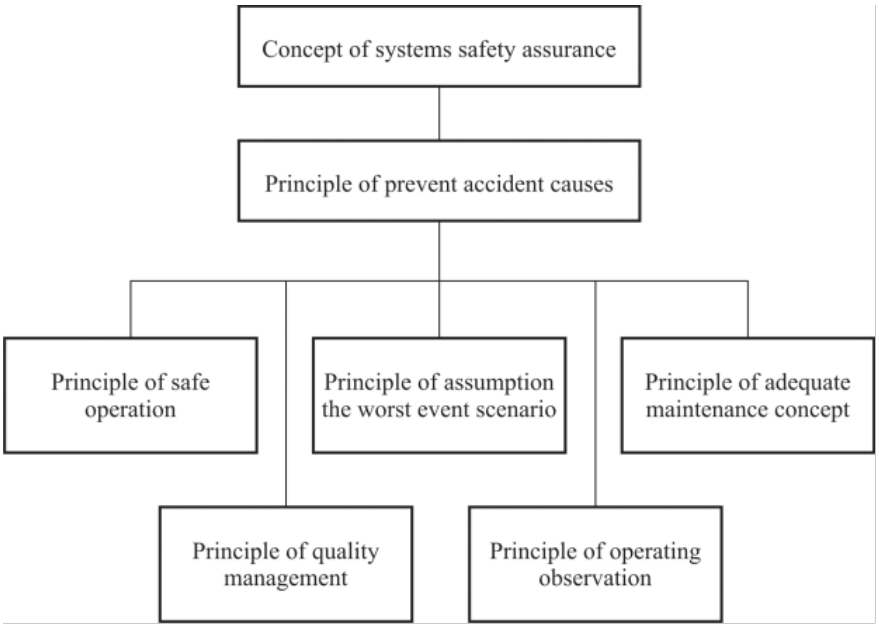

Fig. 4: Safety focussed maintenance and operational concept (Papic et al, 2009:538).

The safety focussed maintenance is premised on the fact that the number of safety incidents and the related disaster effects are dependent of the asset's failure mode (Papic et al, 2009:538). Therefore maintenance should encompass the risk degree, i.e. the consequential aspects related to the failure mode as a prerequisite for the safe maintenance of physical assets (Papic et al, 2009:538). Thus a maintenance system's goal should be ultimately to maintain assets without causing any accidents, see figure displayed below.

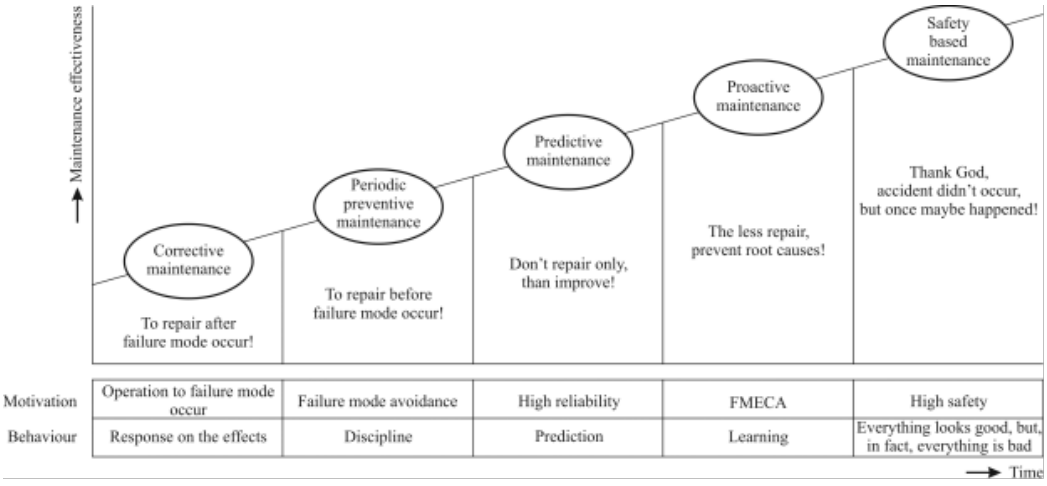

Fig. 5: Maintenance system development towards safety focus (Papic et al, 2009:545)

Recently, safety and environmental compliance with regards to assets and infrastructure have taken centre stage in many countries with usually a complete government department dedicated to safety, environment and energy conservation compliance, and organizations have to apply new green and sustainable technologies (Xia et al., 2018:1).

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4. The South African safety and environmental legislative requirements pertaining to assets maintenance

Within South Africa, the emissions to the atmosphere and environment are governed according to the legislative requirements under The National Environmental Management Act (NEMA). There is a government department of Environment and Energy that is dedicated to ensure that compliance is adhered by all industrial entities within the country. There are heavy fines that are attached to non-compliance to the environmental set limits on emissions that ranges from heavy monetary fines up to cessation of operations until measures to comply are met to the satisfaction of government officials. The National Environmental Management Act defines "environment" as “the surroundings within which humans exist, and these surroundings are comprised of: the land, the water and the atmosphere of the earth; micro-organisms, plant and animal life; any part or combination of the first two items that are listed, and the inter-relationships amongst and between them; and the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.”
In addition, the Environment Conservation Act defines the environment as "the aggregate of surrounding objects, conditions and influences that influence the life and habits of man or any other organism or collection of organisms.” Thus, all industrial assets are mandated to be maintained within the confines of the legislative requirements of the National Environmental Management Act and the Environment Conservation Act of South Africa.
In terms of safety legislative requirements in South Africa, the dominant requirements are found under the Occupational Health and Safety Amendment Act, No. 85 of 1993 (OSHACT 85 of 1993) and the Labour Relations Act, No. 66 of 1995. The OSHACT 85 of 1993 is prominent for its prescriptive approach for maintenance requirements for critical aspects such as construction and maintenance of industrial assets for environmental compliance, maintenance and handling of lead, asbestos and chemical hazardous installations, maintenance and operation of bounded assets such as goods and passenger lifts and escalators, and maintenance and operation of pressure equipment such as boilers and pressure vessels. The OSHACT 85 of 1993, lists the “general duties of manufacturers and others regarding articles and substances for use at work 1) designing, manufacturing, importing, selling or supplying, any article for use at work to ensure, as far as is reasonably practicable, that the article is safe and without risks to health when properly used and that it complies with all prescribed requirements. 2) Any person who erects or installs any article for use at work on or in any premises shall ensure, as far as is reasonably practicable, that nothing about the manner in which it is erected or installed makes it unsafe or creates a risk to health when properly used. 3) Any person who manufacturers, imports, sells or supplies any substance for use at work shall- (a) ensure as far as is reasonably practicable, that the substance is safe and without risk to health when properly used; and (b) take such steps as may be necessary to ensure that information is available with regard to the use of the substance at work, the risks to health and safety associated with such substance, the conditions necessary to ensure that the substance will be safe and without risks to health when properly used and the procedure to be followed in the case of an accident involving such substance. 4) Where a person designs, manufactures, imports, sells or supplies an article or substance for or to another person and that other person undertakes in writing to take specified steps sufficient to ensure, as far as is reasonably practicable, that the article or substance will comply with all prescribed requirements and will be safe and without risks to health when properly used, the undertaking shall have the effect of relieving the first mentioned person from the duty imposed upon him by this section to such an extent as may be reasonable having regard to the terms of the undertaking.”

The OSHACT 85 of 1993 specifies that lifts and escalators are maintained according to section 44 of the act and mandatory inspections are done by a competent and certified service provider at intervals not exceeding 24 months. The act also specifies that the user of the lift or escalator shall appoint a competent service provider in writing and should ensure that the lift or escalator is tested for safety compliance at intervals not exceeding 12 months. The figure below shows pictures of goods lifts that were taken at a manufacturing company in Johannesburg, South Africa.

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(a) (b)

Fig. 6: Goods lifts (a) old and (b) new

In terms of boilers maintenance, OSHACT 85 of 1993 states that the maintenance also need to be carried out as per section 44 of the act, specifying that they need to be inspected and pressure tested to 1.25 times the design pressure by an approved inspection authority. The act also stipulates that every fire-tube steam generator should be subjected to an external inspection and a witnessed hydraulic test and crack detection of critical welds every 36 months.
The OSHACT 85 of 1993 also stipulates that any major incidents should be reported to a government inspector, with those incidents covering the following - (1) Each incident occurring at work or arising out of or in connection with the activities of persons at work, or in connection with the use of plant or machinery, in which, or in consequence of which-
(a) any person dies, becomes unconscious, suffers the loss of a limb or part of a limb or is otherwise injured or becomes ill to such a degree that he is likely either to die or to suffer a permanent physical defect or likely to be unable for a period of at least 14 days either to work or to continue with the activity for which he was employed or is usually employed; (b) a major incident occurred; or (c) the health or safety of any person was endangered and where - (i) a dangerous substance was spilled; (ii) the uncontrolled release of any substance under pressure took place; (iii) machinery or any part thereof fractured or failed resulting in flying, falling or uncontrolled moving objects; or (iv) machinery ran out of control, shall, within the prescribed period and in the prescribed manner, be reported to an inspector by the employer or the user of the plant or machinery concerned, as the case may be.
(2) In the event of an incident in which a person died, or was injured to such an extent that he is likely to die, or suffered the loss of a limb or part of a limb, no person shall without the consent of an inspector disturb the site at which the incident occurred or remove any article or substance involved in the incident therefrom: Provided that such action may be taken as is necessary to prevent a further incident, to remove the injured or dead, or to rescue persons from danger.

5. Conclusion

Safety and environmental compliance for industrial assets is carried out to prevent catastrophic failures that will affect the society, the environment and the economy at large. Failure to comply with the local safety and environmental legislative requirements may result in the stoppage of industrial operations or other punitive fines that impact on the operability of an organization.
The incorporation of safety and environmental aspects in maintenance systems is the way to go in the prevailing scenario as the majority of governments have taken drastic steps to protect the society and the environment through application of legislative measures. Like in the case of South Africa, any serious injuries involving the use of machines have to be reported to the relevant government officials, who then after full investigations would prescribe whether the company was negligent or not, and consequently recommend the actions to be done by the concerned company. Sometimes the operations of a company are suspended until corrective measures are taken to the satisfaction of government officials, or the company is fined a hefty penalty in some instances. The result is that manufacturing organizations in South Africa are now prioritizing maintenance for safety and environmental compliance through recruiting competent maintenance engineers who have gone through training in the

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requirements of the OSHACT 85 of 1993, and in possession of a government certificate of competence. In conclusion, governments these days are pushing for sustainable development, and they require maintenance practices that ensure assets and infrastructure are in compliance with prevailing safety and environmental legislations, therefore it is imperative that organizations align their maintenance practices with the prevailing environmental and safety drive. Otherwise businesses will cease their operations if they don't comply with legislative requirements. The future research areas in maintenance strategies should seek to incorporate sustainability issues if they are to remain relevant for the future generations.

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