On Changing A Light Bulb – A Tutorial

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1. JOKE OR FACT?

Changing a light bulb is probably one of the simplest of everyday tasks. It is also one of the oldest joke topics, with hundreds of *"How many (members of any group) does it take to change a light bulb?"* questions and their weird answers floating around, and compiled on the Internet.

The one most relevant to us here could be this:

"How many safety inspectors does it take to change a light bulb?
"Four: One to change it and three to hold the ladder."

This is not really funny when we note that most accidents and injuries are by falling from heights. In this article, author will use changing a light bulb at home as a simple case study to illustrate the process of risk assessment (RA) and risk management (RM).

2. RISK ASSESSMENT AND MANAGEMENT

Risk management consists of three main phases: (i) Hazard identification, (ii) Risk assessment, and (iii) Risk control, the sequence being preceded by a lot of preparation, and followed by implementation, monitoring, communication, and review.

Of the three main phases, hazard identification is the most important one, because if you do not identify a potential danger, obviously you cannot eliminate or control it.

But after all, what dangers could there be while changing a light bulb?

Well, the answer depends on many factors, some of which are listed below – together with the assumptions we shall make to keep the tutorial short and simple, stated in square brackets.

- Is the replacement bulb the right size, type and wattage? *[We will assume it is.]*
- Can the man reach the bulb holder from a fixed access, or does he have to climb on some temporary platform to reach it? *[We see from the figure that the bulb is about 2½m above the floor, and the man needs to climb about 1m above the floor.]*
- If he has to climb up, what does he stand on: A step-ladder? An upturned box? A chair? A table? Somebody's shoulder? *(Don't laugh – it happens.) [We consider a stool on a table at home.]*
- Is the electric circuit switch under his control, or away from where he has do the work? *[We assume it is an older apartment with no ELCB protection, and mains are outside the room.]*
- Does he have adequate existing light, or is it dark in the area? *[We assume that there is enough existing or extra light.]*
- Is it an open, ventilated area, or a confined space? *[We assume the former.]*
- Is it indoors, or outdoor? *[We assume indoors.]*
- What other activity is going on in the area? *[We assume nothing conflicting.]*
- Is it dry or wet, hot or cold? *[We assume dry and comfortable temperature.]*
- Has he done it before, or is this the first time? *[We assume he knows how.]*

This is just to show that collection of data is an essential part of RA preparation. If you want to be good at RA, you must think up all such questions, get all the answers you can, keeping your eyes and ears open – because if you miss identifying any hazard, you have no chance of preventing or mitigating the accident.

3. HAZARD IDENTIFICATION

3.1. Identify the job steps which may present hazards

From experience, study, consultation, or otherwise, list sequentially all the steps in the job which could possibly involve a credible potential danger. Imagining that you are doing the job is a neat trick! For changing a bulb, the list may cover some ten items like this:

(i) Arrange the means for climbing;
(ii) Turn off power;
(iii) Climb to higher level, with new bulb;
(iv) Remove old bulb;
(v) Place bulb down safely;
(vi) Pick up new bulb;
(vii) Insert bulb into holder;
(viii) Climb down to floor level;
(ix) Turn on power and check bulb; and,
(x) Dispose off old bulb.

3.2. Combine steps with identical hazards

This portion is optional, mainly to save redundant paperwork. Some prefer to leave all the steps in chronological order, and repeatedly enter identical hazards and controls.

However, if we decide to combine identical hazards, the ten hazard steps identified may be consolidated into three group steps, which we may also call basic 'Activities':

1. (i), (iii) and (viii), arrange means to reach holder, climb up and climb down;
2. (ii) and (ix), de-energise and re-energise the circuit;
3. (iv), (v), (vi), (viii), (x), and part of step (iii), all dealing with safe handling of bulb

4. RISK ASSESSMENT

4.1. Determine hazards and existing controls for job steps

Table 1 lists the three consolidated job steps, hazards and existing controls if any for each.

Note that an activity may have more than one hazard, as with job steps 2 and 3.

4.2. Differentiate levels of severity and likelihood

Hazards must be grouped into at least three levels of severity and likelihood, designated (with the author's fetish for simple terminology, as argued in his book, Ref.1) say 'Low', 'Medium', and 'High. More levels may be added only if further distinct items call for special treatment.

The practical question is: 'Low', 'Medium', 'High', etc., with reference to what?

The answer depends on the 'span' of severities and likelihoods, that is, the range from minimum to maximum of all hazards in the job, project, or industry, according to scope of the assignment.

The basis of judgement is that 'Low' is whatever is acceptable and routine part of normal experience; 'High' is whatever is unacceptable under normal circumstances; and 'Medium' is everything in between, whatever is tolerable and necessary to proceed with the job.

Even if it turns out that all severities or likelihoods of the hazards fall into just a single level, it may be a good idea to try to separate them into at least two levels, so that they may have an influence on the outcome.

Table 1. Job steps, hazards, and existing controls

No.	*Activity/Job-step*	*Hazard*	*Existing controls*
1.	Arrange means of reaching holder, climb up and down	Use of unsafe *ad-hoc* means, or wrong use of safe means, may lead to fall	Prior experience
2.	De-energise and re-energise electrical circuit	Circuit remains active or is accidentally activated during bulb change, causing:	
		2.1. Fire	None
		2.2. Electrocution	None
		2.3. Fall due to shock	None
3.	Remove old bulb, insert new bulb, handle bulbs	3.1. Crush, fumble, or drop bulb	None
		3.2. Fall off in confusion	None

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Table 2. Job steps, hazards, and existing controls

No.	Hazard	Existing controls	Consequences	Sever. Level
1.	Use of unsafe *ad-hoc* means, or wrong use of safe means, may lead to fall	Prior experience	1. Fractures	M
2.	Circuit active during bulb change, causing:			
	2.1. Fire	None	2a. Burns, smoke inhalation, death	H
			2b. Property damage, loss	M
	2.2. Electrocution	None	2c. Burns, death	H
	2.3. Fall due to shock	None	2d. Fractures	M
3.	3.1. Crush, fumble, or drop bulb	None	3a. Hand/foot injury	M
			3b. Loss of bulb	L
	3.2. Fall off in confusion	None	3c. Fractures	M

Table 3. Hazards and likelihood levels

No.	Hazard	Likeli-hood	Level
1.	Use of unsafe *ad-hoc* means, or wrong use of safe means, may lead to fall	9 in 10	H
2.1.	Electrical fire	2 in 10	L
2.2.	Electrocution	3 in 10	M
2.3.	Fall due to shock	3 in 10	M
3.1.	Crush, fumble, or drop bulb	3 in 10	M
3.2.	Fall off in confusion	3 in 10	M

4.3. Assess consequences of hazards

List the consequences of different types for each hazard. In this example, we will limit ourselves to physical harm and property damage, treating as inconsequential other consequences such as environmental impact, time delay, and reputation damage. Table 2 presents such a list.

Note that a hazard may have more than one consequence, as in hazards 2.1 and 3.1.

With the man only a metre above floor level, consequence of falls has been limited to fractures, excluding death as not credible.

4.4. Assess severity

Assign a severity level for each of the consequences in Table 1 from one of a set of levels, minimum three. To do this, first arrange them in approximate order of increasing severity. For physical harm, the span of possibilities in this case is:

Bruise – hand/foot injury – fractures – burns – smoke inhalation – death

As explained earlier, designate the minor, acceptable harm items (bruise) as 'Low'; the major, unacceptable harm items (death) as 'High'; and everything else in between, tolerable and to be managed possibly by a visit to the clinic, as 'Medium'.

By similar arguments, property damage due to fire (2b) may be conservatively rated 'High', but with insurance and prompt fire-fighting, it may be treated as 'Medium'; this latter item may need review in a real-life situation. Loss of bulb (3b) will be 'Low' severity.

Enter 'L', 'M', or 'H' for the various consequences in Table 2, as decided.

4.5. Assess likelihood

We normally estimate likelihood, the frequency or probability of occurrence, for the various hazards, not for all the consequences. We then assign the same likelihood value to all the consequences for the hazards with more than one consequence.

Likelihood is usually harder to estimate than severity. Unless you have statistics on the various items, you will have to make an educated guess about how frequently each hazard can happen in the overall job, and set a relative value within the span of values in the job or project.

A worker whose assignment is mainly to change bulbs as his regular workplace will have a pretty good idea of how many times a month the different hazards occur. For a householder, just because he changes bulbs so infrequently, it is not right to put all hazards as of low likelihood. Lacking dependable frequency data, we must look for probabilities.

Rather than directly guess 'Low', 'Medium', etc., one way to estimate probability is to ask yourself: *"Out of ten times that I may change a bulb like this, how many times is this potential mishap likely to happen?"*

From the answer, you may rate 1-2 out of 10 as 'Low', and 9-10 out of 10 as 'High', leaving 3-8 as 'Medium'. Accordingly, the set of likelihood estimates may be as shown in Table 3.

Without robust statistics, it is neither possible nor desirable to refine likelihood estimates further. This is the weakest link in the entire process of RA. One should rather err on the safer side, depending on experience to help improve in subsequent applications.

Once this analysis is done, pick the acceptable probabilities as 'Low', the unacceptable probabilities as 'High', and the in-betweens as 'Medium'.

4.6. Combine severity and likelihood to form risk matrix

With the three levels of severity and likelihood, the risk matrix would be 3×3, with nine risk combinations.

The categorisation for combinations may be as shown in Table 4, with the three cells at bottom left treated as 'Low' risk, the three cells at top right as 'High' risk, and the intermediate diagonal three cells as 'Medium' risk. Again, three risk categories are usually adequate, unless there is need for and experience with more.

Table 4. Risk categorisation

Severity \ Likelihood	L	M	H
High	M	H	H
Medium	L	M	H
Low	L	L	M

Table 5. Hazards, consequences, assessed risk, additional controls, and residual risk
(Levels: S = Severity, L = Likelihood, R = Risk)*

No.	Hazard	Consequences	Assessed Risk			Additional Controls	Residual Risk		
			S	L*	R		S	L*	R
1.	Use of unsafe means, or wrong use of safe means, may lead to fall	1. Fractures	M	H	H	Use ladder, or chair, have watcher	M	L	L
2.	Circuit remains active								
	2.1. Fire	2a. Burns, smoke inhalation, death	H	L	M	Remove and, keep fuse or place watcher at mains, fire extinguisher	M	L	L
		2b. Property damage, loss	M		L	(No additional control)	M		L
	2.2. Electrocution	2c. Burns, death	H	M	H	Remove and, keep fuse or place watcher at mains	H	L	M
	2.3. Fall due to shock	2d. Fractures	M	M	M	-do-	M	L	L
3.	3.1. Crush, fumble, or drop bulb	3a. Hand/foot injury	M	M	M	Shoulder bag, gloves or towel, shoes	L	M	L
		3b. Loss of bulb	L		L	(No additional control)	L		L
	3.2.Fall off in confusion	3c. Fractures	M	M	M	Use ladder, or chair, have watcher	M	L	L

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Table 6. Risk Matrix (Map)

Severity↓	Low Likelihood	Medium Likelihood	High Likelihood
High	[M]→2a	[H]→2c	[H]
Medium	[L]→2b	[M]→2d, 3a, 3c	[H]→1
Low	[L]	[L]→3b	[M]

Table 7. Residual Risk Matrix (Map)

Severity↓	Low Likelihood	Medium Likelihood	High Likelihood
High	2c		
Medium	1, 2a, 2b, 2d, 3c		
Low		3a, 3b	

Thus, from the severity and likelihood levels developed in Tables 2 and 3, the resulting risk level according to Table 4 may be determined for all the eight consequences, as listed in the first five columns of Table 5.

The risk matrix for hazards may now be used as a 'map' to examine our risk status, as in Table 6. We see that there are two High risks (1 and 2c), four Medium risks (2a, 2d, 3a, and 3c), and two Low risks (2b and 3b).

5. RISK CONTROL

Author's 'manthra' (chant) for risk control, expounded in his book (Ref. 1) is simple: 'Low' → "Don't worry about it!"; 'High' → "Don't do it!"; and 'Medium' → "Manage it!".

In our map Table 6, we must reduce the two High hazards (1 and 2c) to at least 'Medium' risk before the task can be attempted.

Further, controls should follow the conventional hierarchy of (i) Elimination, (ii) Substitution, (iii) Engineering controls ('EC'), (iv) Administrative controls ('AC'), and (v) Personal Protective Equipment ('PPE').

Just to go through the exercise, note that elimination of changing the bulb is not an option here. Substitution, say with battery-powered torches, candlelight, etc. also will not be a popular or long-term solution.

We are left with engineering and administrative controls, and PPE to solve our problem. We will apply these as follows to mitigate the risks, identifying the control type in each case:

(a) High risk 1:

This refers to falling off the ad-hoc platform. Indeed, many falls do take place all over the world under similar circumstances with various adverse consequences, although they are not widely publicised because the injuries are often minor.

EC: A 1.5m step ladder will be an inexpensive and very useful accessory in every home, saving numerous accidents for the family. If there is no ladder, using a chair rather than a stool will give some support to the standing man from the chair back.

AC: Having a helper to watch over him and steady him, and also to receive the old bulb or to hand over the new bulb, will be a good step.

These measures would bring the likelihood from H to L, and hence the risk also down from H to L.

(b) High risks 2c, and Medium risks 2a and 2d:

All items under hazard 2 refer to energised circuit during bulb changing. As there is no ELCB, the only recourse is for the man to:

(i) EC: Remove the fuse from the mains and carry it with him while he is changing the bulb, or

(ii) AC: Have a helper stay at the mains to ensure it remains switched off for the duration.

Only then can the likelihood of 2c and 2d be brought down from M to L, and the corresponding risks from H to M and M to L.

Medium risk 2a relates to fire. Its likelihood has already been taken as Low; its high severity may be reduced to M by having a home fire extinguisher handy (EC), in which case the risk will drop from M to L.

(c) Medium risks 3a and 3c:

Items 3 concern the dropping or breaking of the bulb while handling it.

EC: Carrying a shoulder bag will save the man from juggling with two bulbs in one hand. A ladder will usually have a ledge to keep bulbs.

PPE: Using gloves (or at least using a thick towel) to handle the bulb, and wearing shoes will protect hands and feet from injury.

These will reduce the severity of 3a from M to L, and the likelihood of 3c from M to L, and hence reduce both risks from M to L.

These additional controls and their effects are displayed in the last four columns of Table 5.

With these additional controls, the residual risk matrix map will be as in Table 7.

Now there are no High risks, and only one Medium risk. The fact that we still have one Medium risk 2c need not be a cause for concern. As the author has explained in his book, it is better to have Medium risks for certain critical items so that the concerned people will continue to watch their step – satisfying what the author calls the 'compliance regime', very essential in all risk control. Here it only means that the helper must keep continuous and strict watch at the mains to avoid electrocution of the bulb changer.

6. CHANGING A BULB AT THE WORKPLACE

Just for comparison, what about RA for changing a bulb at the workplace? No sweat!

By regulations which must be followed at the workplace, the worker will use a ladder, and he would have been trained to use it correctly. The ladder will have a ledge, and in any case, the worker will have many spacious pockets in his overalls to park the bulbs. He will be wearing gloves and safety shoes. The electrical circuit will be protected with ELCB, and in case of fire there will be automatic sprinklers present, and fire extinguishers available.

If we go through an exercise similar to the above, we will find that all the existing controls would keep all the hazards at the workplace at Low risk level, as long as the compliance regime is followed.

7. CONCLUSION

While changing a bulb may not match the seriousness and complexity of jobs at the construction site or factory floor, it has been selected as an easily understandable case study to illustrate the steps and logic of the thought process which is applicable to almost any situation.

We have taken a long route to reach simple 'common-sense' conclusions. But the journey should have been worthwhile for beginners, and as a review to practitioners.

Author urges readers to comment on the analysis presented herein, and send in similar simple case studies of their own, which the author may share with others via his website: www.profkrishna.com, and/or other newsletters. These contributions may be sent in by e-mail to the author via: safety@profkrishna.com

So now, "How many Singaporeans does it take to change a light bulb?"

"Just one: A reasonably well-informed and sensible adult, with the right attitude!"

8. REFERENCES

1. Krishnamurthy, N., "Introduction to Risk Management", 88p, ISBN: 978-981-05-7924-1, 2007.
2. 'web_loafer', http://sanitybluff.blogspot.com/2005_06_01_archive.html, 17 June 2005, for the line diagram of the man, acknowledged with thanks. Author has added all the background and colour.