

**Health & Safety Laboratory
Harpur Hill
Buxton
Derbyshire
SK17 9JN**



**Ergonomics Comparison of Ionic Systems Ltds'
Ergo-Lite & Universal Long-pole Window
Cleaning Systems**

**Assessment of The British Window Cleaning
Academy's training for use of Long-pole Window
Cleaning Systems**

ERG/04/27

**Project Leader: E Milnes
Author(s): E Milnes BSc. MSc(Eng).
Science Group: Human Factors**

DISTRIBUTION

Craig Mawlam Managing Director – Ionic Systems Ltd.

Dr Lee Kenny HSL Human Factors Group Head
M I Gray HSL Ergonomics – Section Head
M Birtles HSL Ergonomics – Senior Ergonomist
E Milnes HSL Ergonomics – Senior Ergonomist

HSL BDU Archive

PRIVACY MARKING:

This report and the work it describes were undertaken by the Health and Safety Laboratory under contract to Ionic Systems Ltd. Its contents, including any opinions and/or conclusions expressed or recommendations made, do not necessarily reflect policy or views of the Health and Safety Executive.

HSL report approval: M I Gray
Date of issue: 24.01.2005
Job number: JC4900011
Registry file: Ergonomics External Consultancy File
Electronic filename: IonicReport_Ergo_Lite.doc

RESTRICTED: COMMERCIAL

CONTENTS

1.0	INTRODUCTION	1
1.1	Background to developing the Ergo-Lite system	1
2.0	COMPARISON OF ERGO-LITE POLE WITH UNIVERAL POLE	2
2.1	Pole weight comparison	2
2.1.1	Summary of pole weight comparisons	3
2.1.2	Weight of water in tubes	3
2.2	COMPARISON OF TELESCOPIC SECTION LENGTHS.....	3
2.2.1	Ergo-Lite section length	3
2.2.2	Universal pole section length	4
2.2.3	Summary of section length comparisons	4
2.3	GRIP / HANDLE DIAMETER.....	4
2.4	STIFFNESS OF THE ERGO-LITE AND UNIVERSAL POLE SYSTEMS .	5
3.0	REVIEW OF TRAINING PROVIDED WITH LONG-POLE SYSTEM	7
4.0	CONCLUSIONS	9
5.0	REFERENCES.....	11

EXECUTIVE SUMMARY

OBJECTIVES

- To provide Ionic Systems Ltd. with a comparison and evaluation of the key ergonomic related features of the new Ergo-Lite and Universal long-pole window cleaning poles. These features include:
 - Pole weight
 - Section length
 - Grip / handle diameter
 - Flexibility
- To provide an assessment of the content of the long-pole user training package provided by The British Window Cleaning Academy Ltd. (Ionic Systems' sister company), primarily in relation to how it addresses musculoskeletal risk factors.

MAIN FINDINGS

- The 30ft Ergo-Lite pole is 36.6% (2.1kg) lighter than the 30ft Universal pole.
- The 45ft Ergo-Lite pole is 30.3% (2.7kg) lighter than the 45ft Universal pole.
- The 45ft Ergo-Lite pole consists entirely of 6ft sections whereas the 45ft Universal pole consists of a 6ft handle section and 8ft telescopic sections. Both types of 30ft pole consist of 6ft sections.
- The 30ft Ergo-Lite pole has an 11mm narrower grip diameter (40mm) than the 30ft Universal pole (51mm).
- The 45ft Ergo-Lite pole has a 7mm narrower grip diameter (51mm) than the 45ft Universal pole (58mm).
- A subjective assessment indicated that the Ergo-Lite poles, whilst being lighter and thinner than the Universal pole, are nevertheless stiffer.
- The training in working techniques / practices (exposure etc.) provided by the British Window Cleaning Academy Ltd. offer sound advice on ways to reduce the element of musculoskeletal risk which arises from these areas; the physical design of the pole system being the other key factor in determining the overall potential risk.

CONCLUSIONS

- The lighter weight of the Ergo-Lite poles reduces the risk of musculoskeletal discomfort associated with lifting and supporting the poles (compared with similar periods of use of same-length Universal poles).

- The reduced section lengths on the 45ft Ergo-Lite pole mean that it can be extended and lowered using the telescopic facility whilst it remains upright; as opposed to the Universal poles where the 8ft section lengths require the pole to be extended on the ground and either walked up or hauled up. Hauling a pole upright will increase the strain on the shoulders, arms and lower back.
- The grip diameters of both the 30ft and 45ft Ergo-Lite poles are within the optimal range for gripping cylindrical objects. The grip diameter of the 45ft Universal pole is at the higher end of the ideal range. Based on these comparisons it is likely that the 45ft Ergo-Lite pole will be associated with lower levels of forearm fatigue during sustained periods of gripping, compared to the same length Universal pole.
- The Ergo-Lites' greater stiffness means that more of the horizontal stepping forwards – backwards motion will be translated into vertical brush head movements. With a more flexible pole a greater proportion of the horizontal movement can be lost in bending / flexion of the pole. Greater stiffness will also make it easier to move the brush head sideways along a building due to the reduced lag between grip section movement and brush head movement.
- The training provided by the British Window Cleaning Academy Ltd (sister company of Ionic Systems Ltd.) in use of long-pole systems complements the physical improvements in the Ergo-Lite poles. The training addresses all of the exposure, training and technique issues that were raised in HSL's previous report on long-pole systems, whilst also adding details of their own which further address the potential musculoskeletal risks.
- The reduced risk of shoulder, arm and lower back discomfort from using the Ergo-Lite system should not be considered by users to mean that they can work for longer sustained periods. This is because the neck extension postures during use will remain the same regardless of the type of pole being used. However, during periods of work the reduced effort needed to use the Ergo-Lite pole should mean that work / stages of buildings can be completed more rapidly thus allowing users more frequent rest breaks and potentially shorter periods of neck extension.

1.0 INTRODUCTION

This report provides a comparison of Ionic Systems' new Ergo-Lite long-pole window cleaning equipment with their standard carbon fibre Universal pole. The Ergo-Lite and the Universal poles are both 'reach and wash' or long-pole systems for use in the same environments (i.e. cleaning external windows up to approximately 45 feet or 14 metres).

Ionic Systems Ltd developed the Ergo-Lite pole following concerns raised in an HSL report on long-pole systems (HSL Report ERG/01/30). The key physical features that have been focused on in the development of the Ergo-Lite system are; weight, section length, handle diameter and flexibility. The alterations that have been achieved in these areas are described and assessed in the main body of this report.

Ionic Systems Ltd. also offer a training course for customers who purchase reach and wash systems. The training is provided by Ionic Systems' sister company; The British Window Cleaning Academy Ltd. and it is based on their own experience with these systems and takes account of the findings in ERG/01/30. This report provides an assessment of the content of the training course in relation to the previous recommendations.

1.1 Background to developing the Ergo-Lite pole

The impetus for developing improvements in the physical design of poles and focusing on operator training comes from the overall assessment in ERG/01/30 that under certain conditions the long-pole system could present musculoskeletal risks. The key risks areas are the neck and the shoulders:

Any potential risk of neck discomfort is associated with exposure (i.e. how long an operator spends looking upwards) and ERG/01/30 identified ways of managing this risk factor by effective training schedules and informing operators about planning their work / working practices.

The risk of shoulder discomfort is associated with three key factors:

- Pole weight & physical design of the pole;
- Pole use technique;
- Exposure (planning / work practices).

ERG/01/30 identified the need for manufacturers to “*continue to monitor developments in materials with a view to providing lighter poles with similar strength to the current ones*”. Ionic Systems therefore researched and developed a new pole system which is now marketed as the Ergo-Lite, whilst also developing a training package for their customers which provides ways of managing exposure risks.

2.0 COMPARISON OF ERGO-LITE POLE WITH UNIVERAL POLE

The physical features of the Ergo-Lite pole which are different from the Universal system are:

- Weight
- Telescopic section lengths
- Handle diameter
- Stiffness

The ergonomics assessment described in this report is based on comparisons between 30ft and 45ft Ergo-Lite and Universal poles.

2.1 Pole weight comparison

Ionic Systems have specified a higher quality carbon fibre for construction of the Ergo-Lite pole. This allows thinner section tubes to be used, whilst maintaining the overall pole strength.

The weights of the poles and empty water tubes were measured by suspending the poles from a Mecmesin Advanced Force Gauge.

Tables 1 and 2 provide details of the lower weight of the Ergo-Lite system.

Table 1. Weight of poles (kg)

Pole length	Universal pole	Ergo-Lite pole
30ft (9.14m)	5.9	3.8
45ft (13.72m)	8.9	6.2

Table 2. Average weight per foot of pole (kgft⁻¹)

Pole length	Universal pole	Ergo-Lite pole
30ft (9.14m)	0.20	0.13
45ft (13.72m)	0.20	0.14
Mean kgft⁻¹	0.20	0.13

The weight data shows that the 30ft Ergo-Lite pole is 35.6% lighter than the 30ft Universal pole

The 45ft Ergo-Lite pole is 30.3% lighter than the 45ft Universal pole.

The higher percentage weight saving in the 30ft poles is most likely to be because at that length both types have the same number of section clamps. However, the 45ft Ergo-Lite pole has more section clamps than the 45ft Universal pole, thereby adding slightly to the proportion of total pole weight associated with the section clamps.

2.1.1 Summary of pole weight comparisons

Although the advised method of pole use / moving the brush head up and down is to step forwards and backwards, the arms / shoulder muscles must still support much of the poles weight during use and the pole weight is therefore one of the key potential risk factors for shoulder discomfort / musculoskeletal injury. By reducing the pole weight, the risk of shoulder discomfort / injury is reduced (for comparable exposure durations).

For use over significant periods there will also be some energy savings from using a lighter weight pole. Based on a figure of 1064 brush head / cleaning movements over 1 ½ hours of use (including 38% of time as periods of non-pole use), if 47% of these are presumed to be vertical lifts of the pole generated by arm movements, the Ergo-Lite pole would reduce energy expenditure by approximately 1.3kcal over this period. These figures assume a vertical height change of 400mm for each movement cycle. If the pole is used throughout the day the energy savings would be greater. Additional energy savings will be made due to the reduced effort needed to hold the pole during stepping backwards / forwards and at all other times when the pole is held off the ground.

Although there will almost certainly be energy savings with the lighter Ergo-Lite pole, they are likely to be relatively small if it is considered that in general, light physical work uses approximately 150kcal per hour. The greater benefit of the Ergo-Lite poles would be the users' experience that the poles, being lighter, require less effort to use. This will probably have a greater beneficial effect on users' subjective feelings of effort and fatigue.

2.1.2 Weight of water in tubes

Based on a 4mm diameter water tube, the weight of water in a 30ft pole would be approximately 0.11kg and in a 45ft pole it would be approximately 0.17kg. This additional weight would be the same regardless of the type of pole that is used, providing that the water tubing used has the same 4mm diameter.

2.2 COMPARISON OF TELESCOPIC SECTION LENGTHS

- Both the 30ft and 45ft Ergo-Lite poles consist entirely of 6ft sections.
- The 30ft Universal pole also consists of 6ft sections, however the 45ft Universal pole has a 6ft handle section with the remaining sections being 8ft in length.

2.2.1 Ergo-Lite section length

Both Ergo-Lite poles are designed to be made entirely of 6ft sections so that operators can use the telescopic facility to fully raise and lower the pole. This can be achieved by reaching up to the highest closed section clamp and releasing it to allow a pole section to be extended or retracted.

The majority of users will be able to use this telescopic facility / technique whilst keeping the pole upright / resting against the side of the building.

Some shorter users may need to keep the pole in a slightly more horizontal position to reach the section clamps nearest the brush head when raising the pole. However, when lowering the pole short distances this overhead reach capability will not be an issue, all operators (down to 5th percentile female overhead reach distance / 1895mm) will be able to reach the bottom 2 / 3 clamps to allow the pole to retract up to 18ft. Anthropometric dimensions are taken from AdultData (1998).

2.2.2 Universal pole section length

The 45ft Universal poles 8ft main sections means that only very tall males (over 95th percentile in terms of overhead reach distance) will be able to reach the second section clamp. This means that very few, if any, operators will be able to raise and lower the 45ft Universal pole using the telescopic facility while it is in an upright position.

This means that the 45ft Universal pole will have to either be extended on the ground and the user will have to either foot the base and walk it upright, or haul the pole upright from the handle. Hauling the pole upright is not advised because of the additional strain it places on the arms / shoulders and lower back, as well as the physical stress it will place on the pole itself. However, in certain conditions (lone working at a building where footing against a wall etc is not possible) it may not be possible to foot the pole and walk it upright, thus leaving hauling the pole upright as the only means of raising it higher than approximately 15ft.

2.2.3 Summary of section length comparisons

The 6ft main sections of the 45ft Ergo-Lite pole allow operators to extend and lower the pole while it is in an upright position. This will eliminate the need for operators to haul the fully extended pole upright, an action which will place an increased strain on the lower back and the fabric of the pole itself.

2.3 GRIP / HANDLE DIAMETER

Table 3. contains the grip / handle diameters for the Ergo-Lite and the Universal poles.

Table 3. Handle / Grip section diameter (mm)

Pole length	Universal pole	Ergo-Lite pole
30ft (9.14m)	51	40
45ft (13.72m)	58	51

Table 3 shows that the grip section diameter on the Ergo-Lite poles is between 12% (7mm) and 22% (11mm) narrower than the 45ft and 30ft Universal poles respectively.

The generally accepted ergonomics rule of thumb for objects which will require a power grip is that 50mm is acceptable and that a greater gripping force can be exerted when the fingers and thumb are able to interlock around the handle. More detailed research has been carried out which investigated a range of handle diameters (Blackwell et al, 1999). This study found that out of a range of 4 grip diameters (32mm, 41mm, 51mm and 57mm) the optimal diameters were the middle two values (41 and 51mm) and the highest and lowest diameters were associated with lower maximal grip forces.

The Ergo-Lite grip diameters for both pole lengths are therefore in the optimal range for grip diameter. The 30ft Universal pole grip diameter is also within the optimal range however the 45ft Universal pole grip diameter is at the higher end of the ideal scale and in general, users may find that they cannot exert as high a gripping force on the larger Universal pole compared with the other 3 poles. Users may also find that after a period of gripping the poles that the Ergo-Lite poles and the 30ft Universal pole are associated with lower levels of forearm fatigue.

The smaller diameters of the Ergo-Lite poles will have 3 additional benefits:

- The poles will be easier to grip whilst wearing thick gloves;
- They will also be easier to guide with accuracy using the upper / non-lifting / pushing hand;
- The Ergo-Lite poles' smaller cross-section means that they will pick up less wind. In windy conditions (under the recommended maximum 30mph wind speed conditions for safe use) users may need to exert sideways forces on the poles to stop them from being blown over by gusts. It is expected, based on their narrower cross-sections, that the Ergo-Lite poles will not require the same level of effort to oppose these wind effects compared to the same length Universal poles.

Although the thinner handle diameters of the Ergo-Lite poles is beneficial, it is noted that both the Universal pole diameters are nevertheless within the range of grip diameters for effective power grips by the majority of the adult population.

2.4 STIFFNESS OF THE ERGO-LITE AND UNIVERSAL POLES

The stiffness of the poles was compared subjectively by gripping the pole and moving it to judge the relative levels of flexion. The higher specified carbon fibre material of the Ergo-Lite poles means that while they are thinner than same-length Universal poles, they nevertheless feel stiffer.

This additional stiffness will be a benefit to users who employ the recommended cleaning technique of stepping forwards and backwards to move the brush head up and down. The lower flexion in the stiffer Ergo-Lite pole means that a greater amount of the users horizontal movements are likely to be translated into vertical movements, as opposed to being accommodated as pole flexion.

The increased stiffness will also make it easier to control the pole when moving the brush head horizontally along a building / series of windows. The reduction in lag (the delay between the movement of the handle and the brush head) means that there will be less risk of overshooting the next intended work area, or overcompensating for an overshoot of the work area, either of which is likely to increase the strain on the users shoulders and back.

3.0 REVIEW OF TRAINING PROVIDED WITH LONG-POLE SYSTEMS

The previous report on long-pole window cleaning systems identified several areas relating to physical effort and musculoskeletal risk factors which users should be trained in prior to use. These areas are as follows:

- Wherever possible poles should be raised vertically using the telescopic facility. If it is not possible to use the telescopic facility, the pole should be walked up – either by working in pairs or by footing the pole against the base of a building. Users should not ‘haul-up’ extended poles unless these other techniques cannot be used.
- Poles should be used in an optimal upright position and users should be discouraged from using the pole in more horizontal positions i.e. they should use the telescopic facility to reduce the brush height when.
- New staff should begin by using poles up to 10m in length and should be introduced gradually to the use of the pole system (e.g. not using the system for as long each day as an experienced user and taking more frequent breaks).
- Users should ideally reduce the use of their arms by stepping backwards and forwards to move the brush head up and down.
- Ideally the pole length should be selected based on the height of the building. For example a user should avoid using a 45ft pole on a building which only requires the lighter 30ft pole.
- Regular short breaks should be taken throughout the day. These should be interspersed with longer breaks, for example at mid-morning, lunchtime and mid-afternoon.

All of these Musculoskeletal risk reduction steps are now included in the British Window Cleaning Academy’s training package which is provided with the poles. The only measure which is not specifically mentioned in the literature for the Waterfed Pole Course (WFP2) is that of ideally selecting a pole that is not too long (and therefore unnecessarily heavy) for a particular building. This may be due to the lesser feasibility of some smaller operating companies to have a range of pole lengths. It is possible that this aspect of the system is discussed verbally during purchasing and training.

Additional musculoskeletal risk reduction steps recommended in the training are as follows:

- Users should regularly alternate between using their left and right hand as their main supporting / power hand. This provides an effective way of further reducing fatigue in the shoulder of the supporting arm / supporting hand.

- To move the brush head sideways the user should step to the opposite side / direction, the slight angle of the pole to that side will cause the brush head to move sideways. The user can then step back underneath the brush head to hold the pole vertical and stop the brush head moving sideways. This technique uses gravity rather than specific muscular effort in the lower back to move the brush head sideways.

The training offered by The British Window Cleaning Academy Ltd. also provides useful information on tripping hazards, adverse weather conditions, cordoning off areas of work, unstable buildings and effective maintenance.

It is important that larger clients pass on training to any new employees, or request training via Ionic Systems in the use of their systems. Although it may not be necessary for employees to know about the chemical basis for the cleaning system, the physical and musculoskeletal elements to the work and the safety aspects (tripping / cordoning off etc.) are equally applicable to all users of the system.

4.0 CONCLUSIONS

- **Weight:** The Ergo-Lite pole, when used for similar periods as a similar length Universal / Carbon Fibre pole, will cause significantly less strain on the shoulders and arms, and a reduced overall energy expenditure due to its lighter weight.
- **Section length:** The shorter section length of the 45ft Ergo-Lite pole means that users will be able to extend and lower the pole fully, using the telescopic facility. This eliminates the need to haul the pole up when fully extended when it is not possible to walk the pole upright.
- **Grip diameter:** The Ergo-Lite grip / handle diameters are in the optimal range for power grip around a cylindrical object. The 45ft Universal poles grip diameter is at the upper end of what is ideal. Users of the Ergo-Lite pole would therefore be expected to experience less forearm fatigue over sustained periods of use.
- **Stiffness:** The Ergo-Lite poles increased stiffness means that the advised method of use (i.e. moving the brush head up / down by stepping forwards and backwards) will be more suitable and effective. The increased stiffness should also make it easier to move the brush head sideways without using the shoulder and back muscles to compensate for the effects of lag.
- **Training:** The British Window Cleaning Academy's training addresses the key musculoskeletal risk factors relating to working practices, techniques and exposure to physical musculoskeletal risks that were identified in HSL's previous report on long-pole systems (ERG/01/30). Two additional techniques and considerations are also included (technique for moving brush heads sideways and regularly swapping pole from left to right support hand / side of body). Companies who purchase the poles should be made aware of the need to pass on any training to new employees, or alternatively they should contact Ionic Systems (sister company of The British Window Cleaning Academy) to arrange training. The training also covers tripping hazards / cordoning off areas, which is the additional key human factors hazard for long-pole users.
- **Additional Conclusions:** It is important that users do not increase their work durations because of the reduced effort when using the Ergo-Lite poles. The Ergo-Lite poles will not generally reduce the extent of neck extension postures adopted by users, therefore the musculoskeletal risks associated with these postures will potentially remain the same as currently. If users were to increase their work durations due to using the Ergo-Lite poles, this would have the potential to cancel out the beneficial effects of the Ergo-Lites weight reduction, whilst maintaining or increasing levels of risk for neck discomfort. However, the reduced effort needed to use the Ergo-Lite pole may allow users to complete work stages more quickly, thus giving themselves more frequent breaks.

- **Handle Recommendation:** Users are advised to cup / support the base of the pole in one of their hands. However, to provide users with additional scope for adjusting their hand / wrist posture a handle could be fitted at the base of the pole. This would give operators the option of switching between; a) gripping the pole with their support hand, b) cupping the base of the pole with their support hand, and c) supporting the pole using a handle. It may be worth exploring some different designs of handles and carrying out some trials to establish whether this is a feasible and useful modification to the poles.

5.0 REFERENCES

Blackwell, J.R., Kornatz, K.W., Heath, E.M. (1999). Effect of grip span on maximal grip force and fatigue of flexor digitorum superficialis. *Applied Ergonomics* (30). Pp 401-405.

Milnes, E (2001) Ergonomics of Long Pole Window Cleaning Systems. HSL Report ERG/01/30. Report available to the public.

Peebles, B., Norris, B. (1998) AdultData. DTI Publication (DTI/Pub 2917/3k/6/98/NP).