

CHAPTER 3:

METHODS AND PROCEDURES: GATHERING INFORMATION

3.1. Literature search

For the purposes of this thesis, the following databases were searched: Medline, EBSCO HOST, Science Direct, PsycLit, DIALOG and SPORT Discuss. Databases searched on the World Wide Web included: Google.com, MetaCrawler.com, Altivista.com, Biomednet.com and BJM.com. Information was also gathered in the library of the University of Pretoria and through interaction with other physical work capacity experts in South Africa.

3.2. The position identified for the purposes of this study

Seeing that this study was a natural progression from an earlier dissertation, the same position was used for the development of the job accommodation tool. This position is physically-demanding and will from here on in only be referred to as “technician.” These workers are located throughout South Africa in accordance with the needs of the company (SA ELEC) and the group is extremely diverse, including differences in race, culture, age, gender, anthropometrics, work style, work environment and different styles of management.

3.3. Identifying the test battery

The test battery used for the purposes of this study was taken from previous research on the identified position, done by Bester (2003). The process followed to get to the test battery will now be described.

The methods used during the job-analysis process in the study by Bester (2003) consisted of the analysis of the official job-description document for the applicable job (see annexure 1), interviews with relevant supervisors and employees, as well as observations and a video analysis of all the physical tasks being performed by the relevant physical workers on a daily basis.

3.3.1. Analysis of the job-description document

A job-description document was used to assist in the identification of the critical physical work outputs applicable to the identified job, as well as the critical physical tasks that were linked to each job output. Studying the job-description document also provided a good general idea of the most physically-challenging tasks. The next step was to talk to the people who performed these tasks on a daily basis.

3.3.2. Interviews

Interviews were conducted with supervisors, colleagues and technicians. The interviews consisted of two parts: (1) identifying the 10 most strenuous tasks, based on the analysis of the job description and the subjective opinions of the employees being interviewed; and (2) subjectively rating each identified task by means of a 10-point scale (based on the RPE scale). After the interviews were conducted, the ten tasks with the highest average rating were selected for the purpose of the study. The interviewed employees identified the following ten tasks as the most strenuous (all ten of these tasks are used in performing the physical outputs identified through the analysis of the job-description document):

- vegetation control (working with a chainsaw, handsaw, etc.);
- working with a “stamper” (tool that is used to compress sand, rock and gravel);
- digging holes in the ground with a pickaxe and a spade;
- lifting heavy objects from the ground, such as toolboxes, earth bags and branches;
- working with a “riccor” (tool that tightens cable);
- working with a “krimper” (tool that compresses cable);
- lifting a ladder or wooden pole above the head;
- replacing line components (e.g. transformers and conductors);
- stringing (manually pulling cables to cover long distances); and
- foot patrols (walking long distances).

3.3.3. Practical experience / observations and video recordings

Twenty-four hours (two mornings and two full working days) were spent with teams of physical workers in the field. During this time observations and video recordings of all

the identified critical physical tasks were made as they were performed by the physical workers and critical information was written down when applicable. Tools and equipment were also measured for weight, thickness, length, etc.

3.3.4. Video analysis

Once the critical tasks were captured on videotape, as they were being performed in the field, the analysis of the tasks could begin. Each task was thoroughly investigated for movements, body angles, exertions, etc. A qualified ergonomist with experience in working with physical workers assisted in the analysis. The objective was to identify the critical movements and exertions involved in performing each task, as the ultimate objective would be to assess each of these critical movements and exertions in a test battery.

The critical movements and exertions (physical demands) that were identified through the analysis of the ten critical tasks were described as follows:

- lifting heavy objects from the floor to mid-thigh height (one handed) using mainly legs, upper body and arms - toolboxes, earth bags, branches and chainsaws;
- maximal adduction of the arms (pushing two handles together) - “krimper”, “riccor”, and bolt cutter;
- lifting heavy objects above the head (two handed) using mainly arms and shoulders - ladders, wooden poles and pickaxes;
- arm flexion- and general shoulder strength - “stamper”, lifting heavy equipment and tools from a “bakkie” and lifting a “link stick”;
- back extension strength - pickaxe, spade, chainsaw, stringing and lifting a “link stick”;
- leg strength - stringing, lifting heavy objects from the ground and climbing a ladder;
- shoulder endurance - working with smaller tools on (or above) eye level for extended periods when replacing transformers, conductors and other devices;
- cardiovascular endurance - foot patrols; and
- grip strength – involved in all manual tasks.

These nine basic movements and exertions are present in the critical tasks mentioned earlier. In other words these movements and exertions were chosen as the critical physical components / demands that an employee had to be able to perform to a certain extent in order to perform the job satisfactorily. “Balance”, “flexibility” and “trunk stability” were added by SA ELEC and used for the purposes of this thesis as a number of tasks are performed at heights (mostly on ladders), there are a number of bending and stooping tasks and trunk stability is important in most physically-demanding tasks.

3.3.5. The test battery

After Bester (2003) completed a comprehensive pilot study the tests to be used in the test battery were considered to be valid and reliable. It is important to note that Bester (2003) did not design all the tests used for the purpose of this thesis. The electricity supply company, SA ELEC, already implemented a physical ability test battery at that stage and Bester (2003) merely attempted to compliment the test battery that existed with his work specific tests. The idea being that the final product would provide a comprehensive test battery, designed to test all the identified critical physical components / demands.

Here follows the complete test battery used for the purpose of this thesis, including photos, equipment used and detailed descriptions.

3.3.5.1. Safety tests

Because of the physical nature of the physical ability tests it is always critical that all participants complete an informed consent form before the testing starts and that all forms are checked for relevant information. If any problems are identified through the answers of a participant, the biokineticist should deal with it accordingly. It is also very important to assess resting blood pressure before the actual physical ability testing starts. An individual is not allowed to take part in the physical evaluations if his / her resting systolic blood pressure is above 200 mmHg or if the resting diastolic blood pressure is above 120 mmHg (American College of Sports Medicine, 1991). All the normal contraindications for physical activity should be applied during physical ability testing since a number of the tests are physically strenuous.

3.3.5.2. Physical ability tests

3.3.5.2.1. Hamstring- and lower back flexibility

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.1.1. Photo



Photo 3.1: Lateral view of “hamstring- and lower back flexibility”

3.3.5.2.1.2. Equipment

The following equipment is used for this test:

- (1) flexibility stick with fixed measuring tape (80 cm in total); and
- (2) iron balance bar (flexibility stick is fixed on top of balance bar).

3.3.5.2.1.3. Test description

- Subject sits down flat on the floor with his legs straight, facing the flexibility stick.
- The feet must be against the balance bar on either side of the flexibility stick (no shoes).
- Place the hands on top of each other.

- Straighten the arms in front of the body.
- Place the hands on the flexibility stick and place the head between the arms.
- Now slide the hands as far forward on the flexibility stick as possible (knees are not allowed to bend).
- The movement must be fluent without any jerking action and the hands must remain perfectly on top of each other (fingertips in line).
- The subject should hold the furthest position for 3 seconds.
- The test administrator reads the distance from the measuring tape at the furthest point touched by the finger tips (leading finger tips).
- The subject gets two chances and the best effort is recorded in centimeters.

3.3.5.2.2. Hand grip strength (right and left)

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.2.1. Photo



Photo 3.2: Anterior view of “grip strength test” (right hand)

3.3.5.2.2.2. Equipment

(1) hand grip strength dynamometer.

3.3.5.2.2.3. Test description

- Adjust the handle of the grip dynamometer according to the size of the subject's hand. The subject should indicate a comfortable grip.
- Place the grip dynamometer in the subject's right hand. The hand with the dynamometer is held to the side of the body with a straight arm and slightly away from the body (approximately 40 degrees).
- The subject now presses as hard as possible for approximately 3 seconds and then releases the grip.
- The subject gets two attempts and the best result is recorded on the data form.
- The same procedure is followed with the other hand.

3.3.5.2.3. 3 minute step test

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.3.1. Photo



Photo 3.3: Lateral view of “3 minute step test”

3.3.5.2.3.2. Equipment

The following equipment is used for this test:

- (1) step bench (25 cm high);
- (2) stopwatch;
- (3) sound metronome (100 beeps per minute); and
- (4) stethoscope.

3.3.5.2.3.3. Test description

- The subject stands upright next to the step bench, facing the bench.
- The sound metronome is set to 100 beeps per minutes.
- At the “start” instruction from the test administrator, the subject starts to step at exactly the pace indicated by the sound metronome.
- The following sequence is to be repeated by the subject: One foot on bench, other foot on bench (both feet are now on the bench), one foot on the floor, other foot on the floor (both feet are now on the floor).
- The subject starts the stepping with his / her preferred foot.
- The subject steps like this for three minutes.
- At the “stop” instruction from the test administrator (after exactly three minutes), the subject stops stepping and stands upright next to the step bench.
- The heart rate is measured by placing a stethoscope on the left side of the chest of the subject (immediately after the test) and counting the number of heart beats during a 15 second period.
- The “15 second heart rate” is then multiplied by four to get “beats per minute”.

3.3.5.2.4. Arm / shoulder muscle strength

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.4.1. Photo



Photo 3.4: Anterior view of “arm / shoulder muscle strength test”

3.3.5.2.4.2. Equipment

The following equipment is used for this test:

- (1) back / leg dynamometer;
- (2) iron handle bar with rubber grips and 1 meter chain;
- (3) steel platform; and
- (4) cushion bar (fixed on top of the steel platform).

3.3.5.2.4.3. Test description

- First of all the cushion bar is adjusted to the correct height, based on the subject. The subject stands upright next to the cushion bar and the cushion is adjusted to roughly the same height as the hip joint.
- The subject gets onto the platform and lies with his / her sternum on the middle section of the cushion that is attached to the crossbar.

- The arms are put over the crossbar while the feet are wide apart and as far back as possible on the platform.
- The handlebar is held tightly in an overhand grip.
- The arms are bent to an angle of 120° to 130° at the elbow joints.
- The dynamometer is now hooked to the handlebar.
- The test administrator must stand in front of the subject in order to observe the correct angle of the arms and to make sure that the armpits are kept open and not drawn towards his / her body during the pull.
- The subject now pulls as hard as possible on the handlebar without bending the knees or dropping the hips (only the arms and the shoulders are to be used during the pull).
- Two maximum efforts are performed and the highest score (in kg force) is recorded.

3.3.5.2.5. Back muscle strength

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.5.1 Photo

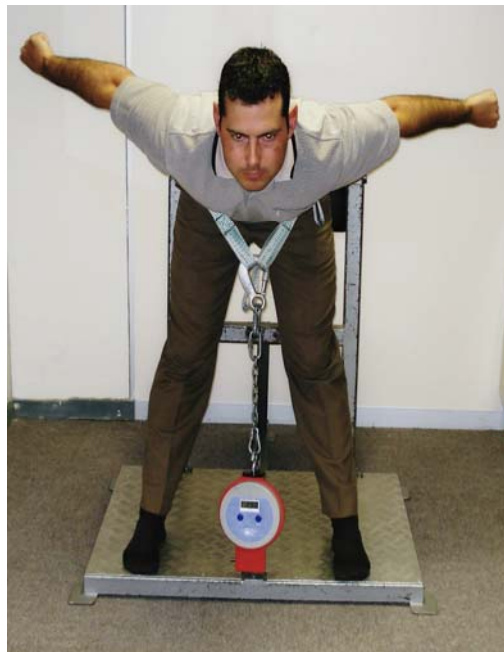


Photo 3.5: Anterior view of “back muscle strength test”

3.3.5.2.5.2. Equipment

The following equipment is used for this test:

- (1) back / leg dynamometer;
- (2) adjustable strap;
- (3) one meter chain with large caribbeener and small caribbeener; and
- (4) steel platform.

3.3.5.2.5.3. Test description

- The back muscle strength test should only involve a straight upward pull with the back muscles, without any involvement of the arms, legs or body mass.
- The subject stands with the feet shoulder width apart and the dynamometer between the feet. The toes of both feet should touch the front edge of the platform.
- The subject bends forward until the hip joint is at approximately 90 degrees (the back must be very close to horizontal and the legs straight).
- The adjustable strap is placed across the upper back, just below the armpits.
- The large caribbeener is used to adjust the strap to a comfortable size by pushing the caribbeener through two of the various loops in the strap (fasten caribbeener securely).
- The chain that is attached to the adjustable strap is now hooked onto the dynamometer with the small caribbeener. The subject is now in place.
- The chain and the subject's legs should remain straight throughout the test.
- Throughout the test the subject must look and keep the eyes fixed on a spot on the wall in front of him or her (the chin must be up).
- This is very important so as to ensure that the subject will pull on the dynamometer with a straight back and thus avoid risk of injury.
- The arms must be kept straight in line with the back, with the hands some 30 centimeters away from the body (airplane position).
- Throughout the test the test administrator must stay at the side of the subject and put one hand on the lower back of the subject (this is to detect any backward leaning of the body).

- Important: The legs and the back must be kept straight during the whole back muscle test.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.

3.3.5.2.6. Leg muscle strength

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.6.1. Photo



Photo 3.6: 45° view of “leg muscle strength test”

3.3.5.2.6.2. Equipment

The following equipment is used for this test:

- (1) back / leg dynamometer;
- (2) adjustable strap;
- (3) one meter chain with large caribbeener and small caribbeener; and
- (4) steel platform.

3.3.5.2.6.3. Test description

- This test is performed shortly after the back muscle strength test, with the feet of the subject in exactly the same spot (shoulder width apart, toes touching the front edge of the platform and the dynamometer between the feet).
- The subject stands upright and the strap (still in place from the back muscle strength test) is pulled downwards to the upper part of the pelvis. If required, the strap can be adjusted by making use of the different loops in the adjustable strap.
- The upper body is bent slightly forward and the knees are bent between 100° and 110°.
- The chain that is attached to the strap is now attached to the dynamometer with the small caribbeener (the chain must be straight).
- The subject pushes / pulls straight upwards against the dynamometer by trying to straighten the legs.
- The test administrator places one hand against the lower back of the subject, so as to detect any backward leaning of the body.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.

3.3.5.2.7. Stomach muscle endurance

Taken from the original SA ELEC “physical ability analysis” test battery.

3.3.5.2.7.1. Photo



Photo 3.7: Lateral view of “stomach muscle endurance test”

3.3.5.2.7.2. Equipment

The following equipment is used for this test:

- (1) stopwatch;
- (2) exercise mat; and
- (3) foot support (another individual can also be used to hold the feet in place).

3.3.5.2.7.3. Test description

- This is a muscle endurance test.
- The test is performed to determine the endurance of the abdominal muscles.
- This test is performed by doing bended knee sit-ups while the feet are kept firmly on the ground by a foot support or another individual.
- The subject lies on his / her back with the knees bent 90°.
- The arms are crossed in front of the chest and the hands are placed on the shoulders.
- When performing the sit-ups, the hands must stay on the shoulders while the subject attempts to touch the knees with the elbows.
- Once the elbows have touched the knees, the subject returns to the starting position (with the back flat on the mat).

- A complete sit-up is counted every time the subject touches the knees with his / her elbows.
- The subject attempts to perform as many sit-ups as possible in the space of one minute.
- A clear command to “start” and “stop” is given as well as a time lapse every 15 seconds.
- Record the number of successful sit-ups performed in one minute on the data form.

3.3.5.2.8. Arm strength above the head

Taken from the “work specific” test battery designed by Bester (2003).

3.3.5.2.8.1. Photo



Photo 3.8: 45° view of “arm strength above head”

3.3.5.2.8.2. Equipment

The following equipment is used for this test:

- (1) iron handle bar – specifically designed for this test;
- (2) 2.5 meter chain (attached to handle bar);
- (3) steel clip (caribbeener);
- (4) back / leg dynamometer, and
- (5) 100 cm x 80 cm steel platform.

3.3.5.2.8.3. Test description

- The subject stands upright on the steel platform with both feet facing the front edge of the platform (dynamometer).
- The feet are little more than shoulder width apart when viewed from the front with the toes of one foot (any foot) touching the front edge of the platform and the heel of the other foot close to the back edge of the platform.
- The back leg is straight at all times and the front leg is slightly bent. This provides a steady base to push from and reduces the tendency to lean backwards during the exertion phase of the test.
- The upper body, neck and head are in a straight line and should remain like that throughout the test.
- The arms are in front of the body with angles of approximately 90 degrees at the shoulder joints and at the elbow joints (before pushing).
- The hands firmly grab hold of the handle bar on opposite sides of the bar, with the broad sides of the bar facing the front and the back. The handle bar must be directly above the dynamometer.
- The subject holds the starting position while the test administrator connects the chain to the dynamometer with the steel clip. It is important to make sure that the subject is still in the correct position when the chain (now connected to the dynamometer) is straightened.
- The subject now pushes the handle bar straight upwards against the dynamometer with maximum effort by using the arms and the shoulders.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.

- The test administrator must be positioned alongside the subject to ensure that there is no backward “leaning” during an effort.

3.3.5.2.9. Lifting strength from the floor (right and left)

Taken from the “work specific” test battery designed by Bester (2003).

3.3.5.2.9.1. Photo



Photo 3.9: Lateral view of “lifting strength from the floor” (right hand)

3.3.5.2.9.2. Equipment

The following equipment is used for this test:

- (1) grip – specifically designed for this test;
- (2) 50 cm chain;

- (3) back / leg dynamometer, and
- (4) 100 cm x 80 cm steel platform.

3.3.5.2.9.3. Test description

- The subject will perform this test on both sides of the body. The photo shows the test being performed with the right hand holding the grip (dynamometer on the right side of the body) and the description will describe it as such.
- Exactly the same guidelines are to be used with the left hand gripping (other side of the body). Therefore all the guidelines still apply, but with the opposite side of the body, the opposite edge of the platform, etc.
- The subject stands on the platform with the right side of the body facing the front edge of the platform (dynamometer). The foot that is closest to the front edge of the platform (the right foot in this case) is placed in the front left corner of the platform.
- The foot that is closer to the back edge of the platform (the left foot in this case) is placed directly in front of the left hip joint with the toes of the left foot touching the right edge of the platform. This starting position is very important as it will assist the subject in pulling straight up, preventing him / her from “leaning” and using the body weight in stead of muscle strength when pulling.
- The subject firmly grabs hold of the grip in his / her right hand and now bends both legs to lower the grip (and the chain that is attached to it) towards the dynamometer.
- The upper body stays virtually straight to prevent excessive strain on the spine and its muscles when the pull is performed (a slight anterior and lateral tilt towards the dynamometer is permitted).
- The chain is attached to the dynamometer and the starting position is quickly rechecked by the test administrator.
- The subject now pulls straight upwards against the dynamometer, pushing upward with the legs and holding onto the grip at all times (leaning is not permitted).
- Two maximum efforts are performed and the highest score (in kg force) is recorded.
- The test administrator must be positioned directly behind the subject to ensure that there is no sideways leaning during the efforts.

3.3.5.2.10. Arm adduction strength

Taken from the “work specific” test battery designed by Bester (2003).

3.3.5.2.10.1. Photo



Photo 3.10: Lateral view of “arm adduction strength”

3.3.5.2.10.2. Equipment:

The following equipment is used for this test (see photo 3.11):

- (1) adduction bars – specifically designed for this test;
- (2) electronic grip dynamometer, and
- (3) 4 cable ties (to fasten dynamometer onto the adduction bars).



Photo 3.11: Adduction bars with grip dynamometer in place (ready for use)

3.3.5.2.10.3. Test description

- The subject stands with his / her back against a wall, with the feet approximately 30 centimeters from the wall and the knees slightly bent. This ensures that the upper body of the subject is against the wall from head to pelvis.
- The upper body must remain virtually straight and against the wall throughout the test.
- The subject firmly grips the adduction bars on the two rubber grips with the narrow end pointing away from the body.
- The bars must remain at an upward angle of approximately 45° at all times. The test administrator may support the narrow end of the bars if required.
- The hands are held at “belt level” (approximately at the same height as the two anterior superior iliac spines) and should remain at that height throughout the test.
- The elbows point outwards.

- The subject now attempts to push the handles together with maximum effort, causing an “arm adduction” action.
- Two maximum efforts are performed and the highest score (in kg force) is recorded.
- The test administrator must ensure that there is no flexing of the trunk during the efforts.

3.3.5.2.11. Shoulder endurance at eye-level (right and left)

Taken from the “work specific” test battery designed by Bester (2003).

3.3.5.2.11.1. Photo



Photo 3.12: Lateral view of “shoulder endurance at eye level” (left shoulder)

3.3.5.2.11.2. Equipment

The following equipment is used for this test:

- (1) 5 kg weight (dumbbell);
- (2) stopwatch; and
- (3) adjustable height bar.

3.3.5.2.11.3. Test description

- The subject stands in an upright position, facing the wall and the adjustable height bar. The adjustable height bar is directly in front of him / her.
- One foot is placed in front of the other and the feet are slightly apart. If the left shoulder is to be tested, the right foot is placed in front and visa versa.
- The subject is asked to make a fist and extend his / her arm straight in front of him / her until the shoulder joint is at 90°. The subject moves the feet forwards or backwards until the fist is exactly under the height bar, but not touching the wall.
- Now the adjustable height bar is adjusted to exactly the same height / level as the eyes of the subject. The adjustable height bar is now at the correct height, the correct distance and exactly in front of the subject (splitting him / her in half).
- The subject is now given the 5kg weight in his / her hand and asked to raise the hand that is holding the weight with a straight arm until the back of the hand touches the adjustable height bar (the palm of the hand must face downwards at all times).
- The moment the back of the hand touches the height bar, the test administrator starts to measure the time with the stopwatch. The goal is to keep the hand against the bottom edge of the height bar for as long as possible.
- The moment the hand drops away from the bar, breaking contact, the stopwatch is stopped and the time is recorded.
- Exactly the same procedure is followed with the other hand.
- The test administrator must be positioned alongside the subject, keeping the eyes on the same level as the point where the hand is touching the height bar.
- Only one attempt is performed with each arm.

3.3.5.2.12. Balance test

This test was designed by the researcher as part of the final “physical ability test battery” for the identified position, and it was also used for the purposes of this thesis. This test battery includes the work specific test battery and the physical ability analysis test battery.

3.3.5.2.12.1. Photo



Photo 3.13: Anterior view of “balance test”

3.3.5.2.12.2. Equipment

The following equipment is used for this test:

- (1) metal balance bar (with 8 cm wide balance beam);
- (2) stop watch; and
- (3) wooden stick .

3.3.5.2.12.3. Test description:

- The subject has to remove his / her shoes for this test.
- The subject firstly stands behind the balance bar, facing it. He / she then grabs hold of the wooden stick (on opposite ends of the stick) and then raises the stick (stick is in a horizontal position) with straight arms to shoulder height.
- The test administrator now asks the subject to climb onto the balance bar with both feet (feet must be approximately 30 cm apart). The balance bar should be directly underneath the balls of the feet.
- The test administrator helps the subject to steady himself / herself by holding the wooden stick steady with the free hand (stopwatch in the other).
- Once the subject is steady, check if the body position is still correct: feet 30 cm apart, wooden stick horizontal and at shoulder height.
- The test administrator now informs the subject that he / she is going to let go of the wooden stick at which moment the timing will start. The test administrator then counts to three, lets go of the stick and starts the timing.
- The subject must attempt to remain on the balance bar for as long as possible without letting go of the wooden stick with either hand or breaking contact with the balance bar with either foot.
- The time is stopped (and the test is over) once the subject lets go of the stick with either hand or breaks contact with the balance bar with either foot (the subject is allowed to move the stick up or down to assist with the balancing as long as the feet and hands remain in place).
- The test administrator must at all times remain in front of the subject, keeping an eye on the hands and feet.
- The subject is allowed two attempts and the best time is recorded.

3.3.5.3. Pre-testing procedure

On arrival at the venue the biokineticist firstly have to prepare the testing area (any large area or room). Ten testing stations are prepared, as well as an area where all the participants could be seated. The ten testing stations are set up as follows:

- (1) station for height- and weight assessment (general information);
- (2) flexibility and grip strength;
- (3) step test and arm / shoulder strength;
- (4) back strength and leg strength;
- (5) stomach muscle endurance test;
- (6) arm strength above the head;
- (7) lifting strength from the floor;
- (8) arm adduction strength;
- (9) shoulder endurance at eye level; and
- (10) balance.

The next step is to get all the subjects at the venue together and to brief them on a few important points concerning the tests and the testing procedures. The group is informed on the following:

- the reasons for the testing;
- how the testing will take place (stations, groups, etc.);
- how each test will be performed (demonstrations);
- important pointers on each test;
- what will be measured with each test;
- the link between each test and the work performed in the field; and
- the importance of the informed consent form and the relevant “safety” questions.

The informed consent form (see annexure 2) is handed out next and each person is asked to complete it. The whole group completes it at the same time as the test administrator goes through the form with them, clarifying each question and ensuring that all

participants understand the importance of their cooperation in answering each question truthfully. Finally the “consent” paragraph is read and explained and each participant is asked to sign the form (if he / she is satisfied and willing to participate). After the completion and signing of the informed consent form, the evaluation form (see annexure 3) is handed out and the participants are asked to complete the personal information section.

3.3.5.4. Procedure during testing

Once the personal information section has been completed everyone remains seated and the blood pressure of each subject is measured. After this “safety test” is completed the large group is divided into smaller groups of four per group. This is done because it is easier for the biokineticist to control a smaller group.

Each group is taken through all 10 testing stations before the next group starts. The group is firstly asked to remove their shoes and excessive clothing such as jackets and hats. This is important for accurate height and weight assessment at station 1. The rest of the stations are subsequently visited where the physical ability tests are performed in the sequence that was mentioned earlier and according to the methods described earlier.

A very important consideration is the matter of sufficient rest between tests. This is ensured by testing the four members of each group in the same sequence throughout all 10 stations. In other words, if a person is tested third at station 1, he / she would be tested third at all the following stations too. This ensures sufficient rest as approximately 5 to 10 minutes are spent at each station, allowing at least 5 minutes of rest for each person in between the tests. It is also very important to provide verbal encouragement for each participant in order to ensure maximum effort at every attempt.

3.3.5.5. Post-testing procedure

During the post-testing procedure the participants are thanked for their time and cooperation and the data form is collected from each person. A few minutes are then

spent with each subject to go through the results and to show how he / she performed compared to the minimum physical requirement for each test.

3.4. Calculating the Minimum Physical Requirements (MPRs)

The cut-off score (also referred to as the minimum physical requirement or MPR) is the test score that an applicant must obtain to be considered for a job (Jackson, 1994; Biddle & Sill, 1999; Bester, 2003).

3.4.1. Statistical analysis

Bester (2003) used the test data of 350 subjects to calculate the minimum physical requirements for his work specific tests. SA ELEC made use of an even bigger data set to calculate the minimum physical requirements for their “factor” tests or “physical ability analysis” tests.

Bester (2003) started by drawing up a histogram for each test to indicate the distribution of the variables against the normal curve. With the data being “representative” of the target population and the distribution of the test data resembling “normal” curves the next step was to arrange the data according to percentiles. This was done to show the variation and the distribution of the data and to break the percentiles up into more manageable increments of 5%. As was the case with the percentiles, the mean, median, mode and standard deviation for each test could be calculated once it had been established that the data was a true reflection of the target population. These measures of central tendency and variation were important as they were used by Bester (2003) during the calculation of the minimum physical requirements (MPR).

The final step was to calculate the minimum physical requirement (MPR) for each test. Which approach to follow in this regard was a tricky question. On the one hand a purely objective and statistical approach would raise questions about the practical relevance of the MPR and on the other hand a purely subjective approach would raise serious questions about the lack of a scientifically viable explanation for the MPR. It was decided to try and find a middle way and to involve both statistical and practical information in

calculating the MPR of each test. The supervisors of the subjects for the Bester (2003) study were approached to assist with their practical experience. The idea was to compare the practically based feedback from these experts with the scientifically based statistical values that were already calculated.

3.4.2. The minimum physical requirements

Table 3 shows the minimum physical requirements (MPRs) for the “technician” position using the test battery as described earlier. The MPR itself is, however, not used to determine whether a subject performed sufficiently in a specific test. This is decided by the “cut score”. The cut score is the actual “cut off” score which decides whether a test score is good enough or not (Jackson, 1994; Biddle & Sill, 1999; Bester, 2003). The reasoning behind this is that one always has to keep practical significance in mind. According to Cohen (1988) one has to look at a measure called “effect size” to measure practical significance. Effect size is independent of units and independent of sample size (Steyn & Ellis, 2006). Cohen’s “d” is used to determine practical significance and when $d \geq 0.8$ the difference between two results are considered to have a large effect, which in turn makes it a practically significant difference (Deng, 2005; Steyn & Ellis, 2006). The formula used to calculate “d” for one sample is:

$$d = \frac{\text{Mean} - \text{Score}}{\text{Standard Deviation}}$$

(Steyn & Ellis, 2006)

This formula is also used to calculate the cut score for a specific test. For the purposes of this study, MPR is used in the place of the mean. This is done because we want to determine which score gives a large effect size in relation to the MPR. We also know that Cohen’s “d” must be at least 0.8 for practical significance and the standard deviation for each test was calculated earlier as part of the process to determine the MPR. This means

that we have all the necessary information to calculate the cut score (C). Arm adduction is used as an example to show how the cut score for each test was calculated (see below).

$$d = \frac{\text{MPR} - \text{Cut Score (C)}}{\text{Standard Deviation}}$$

$$0.8 = \frac{43.9 - C}{13.26}$$

$$13.26 (0.8) = 43.9 - C$$

$$13.26 (0.8) - 43.9 = -C$$

$$- 33.292 = -C$$

$$C = \mathbf{33.292}$$

Table 3.1: The minimum physical requirement (MPR) and the cut score for each test in the physical ability test battery for the “technician” position:

PHYSICAL PARAMETER	MINIMUM PHYSICAL REQUIREMENT	CUT SCORE
Back Muscle Strength (kg force)	103	min 77.0
Leg Muscle Strength (kg force)	220	min 169.2
Arm / Shoulder Muscle Strength (kg force)	93	min 72.3
Grip Strength – Right (kg force)	41	min 34.3
Grip Strength – Left (kg force)	40	min 33.3
Stamina (heart beats / min)	120	max 136
Trunk Muscle Endurance (reps / min)	22	min 13
Lifting strength above head (kg force)	37	min 26.3
Lifting from floor – Right (kg force)	56.5	min 43.2
Lifting from floor – Left (kg force)	56.5	min 43.1
Arm adduction strength (kg force)	43.9	min 33.3
Shoulder endurance – Right (sec)	36	min 21.5
Shoulder endurance – Left (sec)	33	min 19.0
Balance (sec)	4	min 1.4

3.5. Job accommodation tool - breaking the job outputs down into critical tasks

Once the test battery, the critical physical demands, the minimum physical requirements and the cut scores were identified through previous research and existing tools within SA ELEC, it was time to gather new information. This new information would be specific to the job accommodation tool and would be critical in order to ensure that an accurate link between the test battery and the critical tasks, relevant to the identified position, could be made. A thorough job analysis had to take place with specific focus on identifying and understanding all job outputs as well as the tasks related to each output.

3.5.1. Job analysis

Job analysis covers a host of activities, all of which are directed towards discovering, understanding and describing what people do at work (Brannick & Levine, 2002). Shrey and Lacerte (1997) states that the researcher must have a clear and precise understanding of the physical demands for each of the tasks that are crucial to the successful performance of the job. The section on “job analysis”, in chapter 2, takes a look at a few of the popular approaches that could be used. The technique one uses depends to a great extent on the specific purpose. It is usually useful to employ as many information sources as possible to gather information about jobs (Fleishman, 1979; Toeppen-Sprigg, 2000).

A proper job analysis is one of the most critical steps in developing a task specific job accommodation tool. The methods used during the job analysis process in this study consisted of the analysis of the official job-description document of the applicable job, interviews with relevant supervisors and employees (including the use of a questionnaire), as well as task observations and video analysis of all the physical tasks performed by the relevant physical workers on a daily basis.

3.5.1.1. Step 1: Analysis of the job-description document

The job-description document for the technician position was thoroughly studied in order to identify the critical physical outputs and the critical physical tasks related to these outputs. The researcher also consulted with an expert in physical work capacity, as well as with relevant supervisors and technicians. The job outputs on the document were

firstly broken down into specific tasks, followed by the discussion of each task in order to gather as much information about the task as possible. See annexure 1 for the official job-description document for this position.

The main aim of this job-description analysis was to ensure that each output was broken down as far as possible into the smaller tasks that make up each output. In some cases, for example, the tasks mentioned on the job-description document could be broken down into even smaller, more elementary tasks. These tasks would later be used as part of the interview questionnaire and the actual job accommodation tool (the final product). The final list of tasks identified for the technician position was the following (see all tasks next to the black dots):

3.5.1.1.1. Maintenance

Maintenance: Perform vegetation control in company's servitudes

- Operating vegetation control machines: chainsaw
- Operating vegetation control machines: brush cutter
- Operating vegetation control machines: wheat eater
- Manual vegetation clearing: bow saw
- Manual vegetation clearing: panga
- Manual vegetation clearing: axe
- Manual vegetation clearing: branch cutters (on link stick)
- Applying growth control chemicals with "spray gun"

Maintenance: Maintain access routes and security infrastructure

- Installing fences and gates
- Inspecting fences and gates
- Restoring fences and gates
- Restoring & maintaining of roads and drainage systems
- Reporting conditions of roads and drainage systems

Maintenance: Maintain lines and structures: Replacing and securing

- Replacing and securing insulators
- Replacing and securing cross arms
- Replacing and securing bolts and nuts
- Replacing and securing electrical connections
- Replacing and securing anti climbing devices
- Replacing and securing labels and identification markers (pole numbers)

Maintenance: Maintain lines and structures: Cleaning

- Cleaning insulators
- Cleaning cross arms
- Cleaning bolts and nuts
- Cleaning electrical connections
- Cleaning anti climbing devices
- Cleaning labels
- Cleaning identification markers

Maintenance: Maintain lines and structures: Conductor work

- Stringing
- Binding
- Jointing
- Earthing

Maintenance: Maintain lines and structures: Trenches and structures

- Excavating
- Back filling
- Compacting

Maintenance: Maintain lines and structures: Foot patrols

Maintenance: Maintain lines and structures: Vehicle patrols

Maintenance: Maintain substations and control rooms: Security and safety lighting

- Inspecting performance
- Reporting performance

Maintenance: Maintain substations and control rooms: Batteries

- Inspecting batteries
- Topping batteries up with electrolyte
- Cleaning of batteries
- Testing the Specific Gravity of batteries

Maintenance: Maintain substations and control rooms: Reporting any other abnormality found

Maintenance: Maintain substation and control rooms: Executing vegetation control

Maintenance: Work order feedback and clearance

3.5.1.1.2. Repair

Repair: Being on standby

- “Standby” could include any of the mentioned tasks

Repair: Restoring equipment and structures on lines and substations

- Replacing plant and equipment under supervision
- Securing plant and equipment under supervision
- Cleaning plant and equipment under supervision
- Executing foot patrols to identify and report faulty plant
- Executing vehicle patrols to identify and report faulty plant
- Switching on Low Volt networks

3.5.1.1.3. Building

Building: Poles and structures

- Dressing poles and structures
- Erecting poles and structures
- Installing poles and structures
- Dismantling poles and structures

Building: Installing and dismantling

- Installing and dismantling transformers
- Installing and dismantling reclosers and sectionalisers (breakers)
- Installing and dismantling metering points
- Installing and dismantling isolators
- Installing and dismantling drop out fuse links

Building: Conductors

- Conductor stringing (cable pulling)
- Conductor binding (connecting two cables)
- Conductor jointing (attaching cable)
- Conductor earthing

Building: Securing trenches and structures

- Excavating
- Back filling
- Compacting

3.5.1.1.4. Health and Safety

- Reporting all safety incidents, unsafe conditions and abnormal conditions to immediate supervisor

- Inspecting and reporting non-conformance of tools and equipment immediately before use
- Using and caring for personal protective equipment as per requirement
- Effecting statutory and non-statutory appointment

3.5.1.1.5. Customer Service

- Reading cyclic and demand meters on small power users
- Sealing cyclic and demand meters on small power users
- Conforming to the Customer Service Charter
- Giving milestone feedback

3.5.1.1.6. House keeping (maintain an ergonomically sound and hygienic workplace)

- Cleaning of work sites, work stations and infrastructures: Sweeping
- Cleaning of work sites, work stations and infrastructures: Cleaning floors
- Cleaning of work sites, work stations and infrastructures: Cleaning windows
- Executing site restoration in accordance with environmental control measures (restoration in cases of plant growth, storm damage, etc.).
- Executing safe and economic handling, stacking and storing of material
- Erecting barricades and danger notification
- Preparing system earthing (securing high risk work area before working)

3.5.1.2. Step 2: Video analysis

Video recordings of all the critical tasks were studied and analysed. Each task was thoroughly investigated and the objective was to get a clear understanding of the critical physical demands involved in performing each task.

3.5.1.3. Step 3: Observations

All the critical tasks were observed in the field as they were being performed and once again the objective was to get a clear understanding of the critical physical demands involved in performing each task.

3.5.1.4. Step 4: Interviews (with the use of a questionnaire)

Interviews were conducted with 84 specialists in the field of the applicable physically-demanding position which included site supervisors, immediate superiors and technicians. During each interview an interview questionnaire was used and the subject was asked to rate each job output in terms of three rating scales. They were also asked to provide additional input (if necessary) in terms of the further breakdown of job outputs into tasks. This would be very important for the purpose of developing the job accommodation tool. Chapter 4 provides more information on the interviews that were conducted.