An Evaluation of Current Practice in Setting Work Rates

Final Report to WORKSAFE AUSTRALIA

December 1999

by

Wendy Macdonald

Owen Evans

Gerri Nolan

Liz Pratt

Centre for Ergonomics and Human Factors
School of Human Biosciences
LATROBE UNIVERSITY

Funded by WORKSAFE AUSTRALIA
National Occupational Health & Safety Commission

In association with David Caple & Associates, Metal Trades Industries Association, Australian Industries Group and Australian Metal Workers Union

ACKNOWLEDGEMENTS

The project team gratefully acknowledges, most of all, the generous contributions of time and expertise from all participating companies and their employees, who are too numerous to list individually.

The ongoing advice and assistance of the Steering Committee have been greatly appreciated by the research team. Particular thanks are due to Deborah Vallance of the AMWU for her invaluable help and advice as a Steering Committee member, and her assistance in liaising with union members within participating companies; David Caple for his important contribution to the initial project development and his tireless support throughout; and Ann Taylor of the MTIA who was very helpful both in recruiting companies to the project and in development of the questionnaire formats.

Modapts analyses during Stage 2 of the project were performed by Michael Hui with his usual expertise.

PROJECT SUMMARY

BACKGROUND

The project originated because of evidence that:

- Formal methods used to set work rates, including pre-determined motion time systems (PMTS) such as Modapts, do not always take adequate account of task difficulty, and
- Work rates or targets are better accepted by workers who have participated in the process of setting their levels.

The primary issues and questions addressed by this project were:

1. **CURRENT PRACTICE IN SETTING WORKRATES**
   What processes are currently used to set line speeds or production targets?

2. **EMPLOYEE PARTICIPATION**
   How much are the operators themselves able to participate in the process of setting line speeds or production targets?

3. **TASK DIFFICULTY AND WORKLOAD**
   Does current practice take adequate account of the difficulty or demands of the tasks being performed?

4. **PERCEIVED ACCEPTABILITY OF WORK RATES**
   What are the main factors predicting employee perceptions of the acceptability of their work rate?

5. **EMPLOYEE STRESS AND FATIGUE**
   What are the main factors predicting employee levels of stress and fatigue?

6. **IMPROVING CURRENT PRACTICE**
   How should current practice be changed to improve both the well-being of employees and the productivity of their employing organisations?

OVERVIEW OF METHODS AND PROCEDURES

The project was conducted in two main stages, with temporal overlap between the two because of the unavoidably slow rate at which participating companies were recruited. Stage 1 focused on a survey of selected tasks, and in Stage 2, more in-depth analyses of a subset of these tasks were performed.

Stage 1 – Company Recruitment and Survey

Stage 1 included preliminary interviews with one or more company representatives to determine whether (a) the company would be prepared to participate in the study, and (b) the company had one or more tasks suitable for inclusion in this project: repetitive, paced by the production process or by a production target, with several employees per task who spent a substantial part of their work time on that task and who were potentially available for interview.

In Stage 1, data were collected concerning 82 work tasks from staff of 20 companies. For two of these companies data were collected at two different work sites. Questionnaires were administered by personal interviews, and were conducted with:

- 37 Production Managers or Supervisors
- 12 staff with responsibility for OH&S
- 210 employees familiar with the specific tasks nominated for investigation.

It was initially intended that there should be equal numbers of interviews with people responsible for production and people responsible for occupational health and safety; however, in many cases the company reported that no designated employee had specific responsibility for OH&S, resulting in only 12 interviews in this category.

Questionnaire formats were developed in consultation with the Project Steering Committee, and were pilot tested with representatives of the target populations.

Stage 1 questionnaires obtained information on:

- the task: number of separate sub-tasks; nature of *task demands* (both physical and mental aspects); cycle time, indicating degree of *repetitiveness*
- ways in which work on the task was externally *paced*, e.g. by a moving line, by the need to achieve a specified production target, to meet a particular deadline or to fulfil an order
- formal *methods* and/or informal processes used *to set the rate* at which work was paced (e.g. time study, Modapts, industry standards, past experience)
- perceived benefits and shortcomings of currently used methods
- factors believed to affect actual work rate on the task
- the extent to which workers felt they *participated* in the determination of their own work rate on the task, the extent to which they could decide exactly how to do the task, and more broadly, the extent to which they felt they had ‘a say’ in things at work
- workers’ perceptions of the relative importance of maintaining *speed versus quality* when working on the task
- workers’ evaluations of the *acceptability of the required work rate* (e.g. of the line speed or production target for the task)

- workers' *perceptions of* the overall *difficulty* of the task, and of their own levels of mental and physical *effort* in performing it
- information about *the participants*: size of the *worksite* (number of employees), and information about *individuals*: job title, time in that job, age, gender, place of birth, languages spoken.

Stage 2: Task & Job Analyses

In Stage 2, more extensive data were collected about a subset of 36 work tasks within 10 companies. Additional data were collected about both the nature of task demands and their effects on employees doing the task, including:

- measures of postural demand, using OWAS and/or RULA (see Appendix C)
- a measure of heart rate increase above rest
- measures of forces exerted, using the University of Michigan 3D Static Strength Prediction Program and/or Snook Tables (see Appendix D)
- measures of mental workload, using scales based on those of the NASA Task Load Index (TLX), with modifications and additions to meet the requirements of the present project. Scales used were: physical demand, mental demand, time pressure, effort, frustration – all standard TLX dimensions – plus 'working carefully to avoid errors', 'working automatically or thinking things out', and fatigue (see Appendix E)
- a standardized measure of the quality of job design – the Motivating Potential Score (MPS) from the Job Diagnostic Survey (JDS - see Appendix E)
- standardized measures of two dimensions of stress: 'stress' (positive and negative emotions) and 'arousal' (level of activation), using the Stress-Arousal Checklist (SACL – see Appendix E)
- standardized measures of job satisfaction from the Job Diagnostic Survey (JDS - see Appendix E).

RESULTS: PRIMARY ISSUES & QUESTIONS

1. CURRENT PRACTICE IN SETTING WORK RATES

What processes are currently used to set line speeds or production targets?

Work Pacing Factors

Documenting "current practice" in setting paced work rates or targets proved to be difficult because of the range of factors, often inherent in the production system itself, which 'paced' work performance and hence, in varying combinations and to varying degrees, determined work rates.

Major pacing factors were:

- machine operating or production process time – 62.3% of tasks (including the 13.5% of all tasks where there was literally a moving 'line' speed, and the 16% classified as 'end of line')
- production targets – 70% of tasks
- production orders and related deadlines – 46% of tasks.

For many tasks, more than one of these determinants applied, as is evident from the fact that the sum of the above percentages is well over 100%.

What processes are currently used to set line speeds or production targets?

Formal Methods

- Formal methods of calculating appropriate levels for production targets or line speeds were used for 48% of the tasks surveyed

- Of the subset of tasks for which a formal method had been used, Time Study (some form of timing, often fairly informal, of task performance) was reported for 72%, or 34.5% of the total task sample; some form of standard times – based either on industry standards or using a predetermined motion time system (PMTS) such as Modapts – were reported for 28%, or 13.5% of tasks in the whole sample. Undoubtedly the percentage for standard times (PMTS) is an overestimate of the actual incidence in the total population, since a deliberate effort was made to locate companies using these methods and it proved difficult to find many such companies.

Benefits Of Formal Methods

(identified by Production Managers)

- greater validity, fairer
- helps to deal with related complaints; helps to diagnose production problems
- assists with standardising and forward planning, particularly of staffing
- reduces waste, helps job costing, enables more accurate pricing
- can make progressive modifications as required.

Counter-indications For Use Of Formal Methods
(identified by Production Managers)

- new or irregular job; insufficient time
- lack of skill or resources to apply
- off-line jobs, e.g. repairs
- jobs not sufficiently repetitive.

Informal Determination of Work Rates

It was sometimes reported that expectations concerning work rates were largely based on the responsible manager's or supervisor's past experience with that kind of 'job'. This is not surprising given the significant proportion of tasks where machine operating or production process time, often with little or no variability possible, was a major factor determining work rates (as reported above). Also, for 15.4% of tasks neither production target nor line speed were relevant factors.

Other Factors Influencing Work Rates

Increases In Line Speed Or Target Due To Increased Production Requirements?

- One of the 10 production managers responsible for 'line speed' tasks reported sometimes increasing line speed to deal with a requirement for increased production output.
- Seven of the 24 production managers responsible for 'target' tasks reported sometimes increasing production targets to achieve the required output or to meet a deadline for an order.

Factors Reported By Employees To Influence Their Actual Work Rates (Self-Determined Or Otherwise)

Common reasons suggested by employees for sometimes working faster:

- to finish an order by a set time
- to deal with a large backlog
- to supply people in another section of the plant
- process holdups, machine problems
- poorer quality of materials, products
- lower than normal staffing level

In response to specific questions:

- 73% reported having to slow down looking for rejects, or to maintain product quality
- 62% reported being affected by their own personal standards regarding work rate, or by social norms (particularly the former)
- 29% reported varying their speed in response to perceived management attitudes (about equal numbers reporting faster or slower rates).

2. EMPLOYEE PARTICIPATION

How much are the operators themselves able to participate in the process of setting line speeds or production targets?

Knowledge of how targets or line speeds are set?

- For both 'target' and 'line speed' tasks, approximately 67% of employees on such tasks claimed to know how speed or target for the task was set, although answers were typically very vague (e.g. "the engineer decides")

Amount of 'say' in setting targets or line speeds, and in how the task was done

- The majority of employees on such tasks felt that they had no influence on either targets (57%) or line speeds (64%)
- In contrast, 86% felt that they had at least some say in changing how the task was done

Satisfaction with their amount of 'say'

- The majority (62%) were satisfied with their overall amount of 'say'.

3. TASK DIFFICULTY AND WORKLOAD

Does current practice take adequate account of the difficulty or demands of the tasks being performed?

Employees' perceived levels of effort and task difficulty ('workload')

- For these tasks, employee ratings of required mental and physical effort were similar; mental effort tended to be higher but the difference was not significant. Ratings of physical and mental effort and of overall task difficulty were significantly correlated with scores based on an independent analysis by the research team of Physical Demand and Mental Demand (summed as Total Demand) for each task.

Determinants of Physical Effort Rating

A multiple regression model to predict Physical Effort rating showed that factors predicting *low* ratings, in approximate order of their influence, were:

- low Total (Mental plus Physical) Task Demand Score
- use of a Predetermined Motion Time System or standard times to set work rates
- smaller worksite (less than 100 employees).

Determinants of Mental Effort Rating

A multiple regression model to predict Mental Effort rating showed that factors predicting *low* ratings, in approximate order of their influence, were:

- low Mental Task Demand Score
- absence of production targets
- smaller worksite (less than 100 employees).

Determinants of Task Difficulty Rating

A multiple regression model to predict employee ratings of task difficulty showed that low ratings were predicted by:

- low Total Task Demand Score
- smaller worksite (less than 100 employees).

From these results it was evident that:

◊ Researchers' Task Demand Scores were predictive of employee ratings of Effort and Task Difficulty
◊ Employees with production targets rated mental effort as higher
◊ Employees whose work rate had been calculated using standard times rated physical effort as lower
◊ Employees working on in larger worksites rated their effort and task difficulty as higher.

4. PERCEIVED ACCEPTABILITY OF WORK RATES

What are the main factors predicting employee perceptions of the acceptability of their work rate?

Acceptability to employees of work rates

- Despite their lack of 'say' in setting rates, the majority of employees (65%) rated their target or line speed as 'about right'. Of the others, many more responded that they were too high (30%) rather than too low (5%).

Effect of amount of employee 'say'

- For tasks with set targets there were significant relationships between employee ratings of their target as too high and ratings of amount of 'say' as too little – in setting the target, in how the task is done, and overall. There were no such relationships for tasks where work rate was set by line speed.

◊ Thus, lack of 'say' was more likely to cause dissatisfaction when there was a target than with line speed determining work rate.

Predictors of Work Rate Acceptability

Multiple regression analyses to predict ratings of Work Rate Acceptability showed that *high* acceptability ratings were predicted by:

◊ low task difficulty (low rating of Overall Task Difficulty, working most of the time 'on auto')
◊ high ratings of Overall 'Say'
◊ quality rated as more important than work rate
◊ low ratings on Fatigue.

These findings were consistent with project hypotheses.

5. EMPLOYEE STRESS AND FATIGUE

What are the main factors predicting employee levels of stress and fatigue?

Predictors of 'Stress' – the dimension of the Stress Arousal Checklist (SACL) that reflects negative feelings

A multiple regression model to predict Stress showed that high ratings were predicted by the following factors, in approximate order of influence:

- high mental workload (mean of modified TLX scale ratings)
- low Motivating Potential Score (MPS, from the Job Diagnostic Survey)
- short task cycle time
- work rate was determined by production process, machine time or line speed.

Thus, 'Stress' was higher with high workload, an unsatisfying job, and a highly repetitive task in which work rate is largely determined by the machine/ process time or line speed.

Predictors of 'Arousal' – the SACL dimension that reflects activation level

A multiple regression model to predict Arousal showed that high ratings were predicted by the following factors, in approximate order of influence:

- work rate influenced by orders, deadlines
- high Effort rating
- high Motivating Potential Score (MPS)
- high Total Task Demand Score
- high rating on 'working carefully to avoid errors'
- high Postural Stress Score.

The strongest predictor of Arousal was working to meet orders or deadlines. Like 'Stress', Arousal was also influenced by workload – in this case represented by researcher scores for Total Task Demand and Postural Stress, and employee ratings of Effort and 'working carefully to avoid errors'. In this case a more satisfying job (high MPS) was related to high Arousal contrasted with low 'Stress'. (In fact, both dimensions together comprise an overall Stress score.)

Arousal was higher when standard times were *not* used in setting work rates – a result which is consistent with the finding that ratings of Physical Effort are also higher when standard times are not used.

Predictors of Fatigue

A multiple regression model showed that high Fatigue ratings were predicted by:

- high mental workload (mean of modified TLX scales)
- low scores on the General Satisfaction scale of the JDS
- *absence* of orders or deadlines as an influence on work rates
- low rated acceptability of the work rate.

These results indicate that feeling fatigued is not simply a physical phenomenon. As would be expected, fatigue is greater with higher mental workload and work rates perceived as unacceptably high. However, it is also higher when there are no orders or deadlines, suggesting a possible effect of low arousal or boredom, and it is higher when general job satisfaction is lower.

SUMMARY OF RESULTS

Confirming project hypotheses, significant improvements could be expected in many workplaces if changes were made:

- to increase employee sense of being able to 'have a say' in issues affecting them
- to make more adequate allowance for task difficulty – both physical and mental task demands – in determining required work rates
- to improve job design to increase its potential for providing job satisfaction (increased task cycle times; also, increased feedback, autonomy, task variety, task significance, task identify – factors assessed by the Job Diagnostic Survey)
- to reduce the extent to which individual employee performance and hence productivity is limited by the timing of production processes and machine cycle times.

A hypothesis that was *not* confirmed was that:

- the extent to which actual workrate exceeds the Modapts-calculated rate would be predictive of the above dependent variables.

This appeared to be because the extent of discrepancy between actual workrates and Modapts-calculated rates was often influenced by delays due to the employee having to wait for machine or process times, and sometimes simply due to insufficient work to fully occupy them. For this reason, it was difficult to evaluate the effectiveness of PMTS in setting appropriate work rates from present data.

However, the main conclusions of this project, related to the initial hypotheses, are clear. It is also clear that 'best practice' in setting work rates must vary significantly in accord with the widely varying work tasks and production systems. Despite the present project sample size being more limited than initially planned, many of the evident differences related to different production systems were statistically significant, as summarised below.

Rate Set By Time Study, Timing
These tasks were:

- More likely to have targets
- Less likely to have work rate influenced by production process or machine time
- More likely to be on larger worksites.

Rate Set By PMTS, Standard Times
With these tasks there:

- More likely to be orders, deadlines
- Physical effort ratings were lower
- 'Arousal' scores lower

- Likely to have more 'say' in how the task is done.

Rate Determined Or Affected By Production Process And Machine Operating Time (Including Line Speed)

With these tasks there tended to be:

- Cycle times shorter
- Target less likely
- Time Study/Timing less likely
- Total Task Demand score lower
- Physical Task Demand score lower
- Postural Stress score lower
- 'Stress' higher (esp. if short cycle time)
- 'Arousal' lower
- Motivating Potential Score lower
- Smaller worksite (less than 100 employees).

Rate Affected By Target

With these tasks:

- 65% of these people said that the required work rate was acceptable
- Managers were more likely to increase required rate in response to increased output requirement
- More likely to have Time Study or other timing
- 57% reported having no 'say' or influence on level of the target
- Higher levels of 'say' in how the task is done
- More likely to be rated as too high when little 'say'; i.e., lack of 'say' is more problem with targets than with line speeds
- Mental effort higher
- Mental Task Demand score higher
- Total Task Demand score higher
- Larger worksite (more than 100 employees).

Rate Affected By Deadlines, Orders

With these tasks:

- The deadline/order was a commonly reported cause for 'sometimes working faster'
- Cycle time longer
- Total Task Demand score higher
- Postural Stress score higher
- 'Arousal' levels higher
- Fatigue ratings lower
- Average satisfaction higher.

Cycle Time Of Task

For tasks with *longer* cycle times it was more likely that:

- Work rate *not* determined or affected by the production process or machine operating time
- Work rate affected by deadlines, orders
- Task Demand scores (physical, mental and total) higher
- Cardiac cost higher

- ‘Stress’ lower
- ‘Arousal’ higher.

Rate Affected By Process Hold-Ups, Machine Problems, Poor Quality Of Materials
- Frequently cited as reasons for need to work faster to catch up
- Decreasing reject rate, or increasing conspicuity of defects, would very beneficially affect task difficulty, work rate and stress.

Smaller Worksites (less than 100 employees):
are more likely to have:
- PMTS, Standard Times
- Cycle times shorter
- Total Task Demand Score lower
- Mental Task Demand Score lower
- Postural Stress Score lower
- Physical Effort rating lower
- Mental Effort rating lower
- Overall Task Difficulty ratings lower
- Time Pressure rating (TLX) lower
- Effort ratings (TLX). lower

6. IMPROVING CURRENT PRACTICE

How should current practice be changed to improve both the well-being of employees and the productivity of their employing organisations?

The general findings of this project were clear, but in view of the wide diversity of in current practice within different types of production system and work places, more specific recommendations regarding improvements within any given workplace, based on project findings, need to be developed on the basis of:
- effective dissemination of findings to managers and employees within individual workplaces, to facilitate
- a higher level of manager and employee participation in the process of identifying and implementing applications of the results within the specific contexts of their own workplaces.

Such a process will require:
- the establishment of information resources to support workplace change, including
- education and training material, and
- ongoing updating of such resources.

REFERENCES

Addison, M. and Macdonald, W.A. (1993) Use of subjective and objective techniques in identifying injury risk in a light repetitive task - a case study. *Conference of the Australia and New Zealand Modapts Association*, Melbourne.

Blewett, V and Shaw, A (1995) OHS best practice column: integrating OHS through self-managed teams. *The Journal of Occupational Health and Safety – Australia and New Zealand*, 11, 1, 15-19.

Burke, R.J., 1993. Organizational-level interventions to reduce occupational stressors. *Work & Stress*, 7, 1, 77-87

Carayon, P., 1993. A longitudinal test of Karasek's Job Strain model among office workers. *Work & Stress*, 7, 4, 299-314

Chaffin, D.B., Martin, B.J. and Andersson, G.B.J. (1999) *Occupational Biomechanics* (3rd ed) New York:Wiley

Corlett, E.N. (1995) The evaluation of posture and its effects. *In* J.R.Wilson, and E.N.Corlett, (Eds) *Evaluation of Human Work.* (2nd ed.) London:Taylor & Francis.

Cox, T and Griffiths, A. (1995) The nature and measurement of work stress: theory and practice. *In* J.R.Wilson, and E.N.Corlett, (Eds) *Evaluation of Human Work.* (2nd ed.) London:Taylor & Francis.

Cox, T., 1978. *Stress*. Basingstoke, Hants: Macmillan.

Forester, C. and Macdonald, W.A. (1994) Evaluation of the human-computer interface used by switchboard operators. *Journal of Occupational Health and Safety - Australia and New Zealand*, 10(4), 343-351.

Fried, Y. (1991) Meta-analytic comparisonof the Job Diagnostic Survey and Job Characteristics Inventory as correlates of work satisfaction and performance. *Journal of Applied Psychology*, 76, 5, 690-697.

Hackman, J.R. and Oldham, G.R. (1975) Development of the Job Diagnostic Survey. *Journal of Applied Psychology*, 60, 2, 159-170.

Hackman, J.R. and Oldham, G.R. (1980) *Work Redesign*, Reading, Addison-Wesley.

Hancock P.A. & Meshkati N. (Eds) (1988) *Human Mental Workload*. Amsterdam: North-Holland.

Hart, S.G. and Staveland, L.E., 1988. Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In: P.A. Hancock and N. Meshkati (Eds), *Human Mental Workload*, pp.139-183, Amsterdam: North-Holland.

Heyde, C (1976) *The Sensible Taskmaster*. Sydney, Heyde Dynamics.

Hockey, G.R., Briner, R.B., Tattersall, A.J. and Wiethoff, M. (1989) Assessing the impact of computer workload on operator stress: the role of system controllability. *Ergonomics*, 32, 1401-1418.

Hoffmann, E.R. (1992)Predetermined Motion Time Systems for estimation of task times: capabilities, limitations and possible alternatives. *In* M. A Regan (Ed.) *Proceedings of a seminar conducted by the Victorian Branch of the Ergonomics Society of Australia*, Canberra: E.S.A.

Hoffmann, E.R., Macdonald, W.A. and Almond, G.C. (1993) Quantification of the cognitive difficulty of mail sorting. *International Journal of Industrial Ergonomics*, 11, 83-98.

Ivancevich, J.M. and Ganster, D.C. (Eds), 1987. *Job Stress: From Theory to Suggestion*, New York: The Haworth Press.

Jex, H.R. (1988). Measuring mental workload: problems, progress, and promises. *In:* Hancock, P.A. and Meshkati, N. (Eds.), *Human Mental Workload*, Amsterdam: North-Holland.

Johansson, G. (1981) Psychoneuroendocrine correlates of unpaced and paced performance. *In* G.Salvendy and M.J.Smith (Eds.) *Machine Pacing and Occupational Stress*. London: Taylor & Francis.

Johansson, G., Aronsson, G. and Lindstrom, B.O. (1978) Social psychological and neuroendocrine stress reactions in highly mechanised work. *Ergonomics*, 21, 583-599.

Kantowitz, B.H., 1987. Mental Workload. In: P.A. Hancock (Ed.), *Human Factors Psychology*, Amsterdam: North-Holland.

Karhu, O. Kansi, P. and Kuorinka, I. (1977) Correcting working postures in industry: a practical method for analysis. *Applied Ergonomics*, 8, 199-201.

Kelloway, E.K. and Barling, J. (1991) Job characteristics, role stress and mental health. *Journal of Occupational Psychology*, 64, 291-304.

Kroemer, K.H.E. and Grandjean, E. (1997) *Fitting the Task to the Human. (5th ed)*, London:Taylor & Francis.

Luczak, H. (1997) Task analysis. *In* G.Salvendy (Ed.) *Handbook of Human Factors (2nd ed)*, New York: Wiley.

Macdonald, W.A. (1995) Overview of ergonomics methods for analysing or evaluating psychological factors and demands. Course Notes: Master of Ergonomics, La Trobe University.

Marmot, M (1994) Work and other factors influencing coronary health and sickness absence, *Work and Stress*, 8, 2, 191-201.

Marsella, A.J., 1994. The measurement of emotional reactions to work: conceptual, methodological and research issues. *Work & Stress*, 8, 2, 153-176.

McAtamney, L. and Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, 24, 91-99.

McGrath, J. and Zarb, V., 1992. *MODAPTS and its Relationship to the Measurement of Mental Workload in Industry*. Research project conducted under the supervision of W. Macdonald, in partial fulfilment of the requirements of the Graduate Diploma in Ergonomics, La Trobe University.

O'Bryan, S.J., Macdonald, W.A. and Evans, O.M., 1991. A comparison of some workload analysis techniques. *Proceedings of the 27th Annual Conference of the Ergonomics Society of Australia*, pp. 139-147, Canberra: Ergonomics Society of Australia.

O'Hanlon, J.F. (1981) Stress in short-cycle repetitive work: general theory and empirical test. *In* G.Salvendy and M.J.Smith (Eds.) *Machine Pacing and Occupational Stress*. London: Taylor & Francis.

Orr, S. and Wells, R. (1994) The effect of work speed and task precision on perceived fatigue and muscle actication in the arms and shoulders. *Proceedings of the International Ergononmics Association*, 5, 318-320.

Salvendy, G. (1981) Classification and Characteristics of paced work.. *In* G.Salvendy and M.J.Smith (Eds.) *Machine Pacing and Occupational Stress*. London: Taylor & Francis.

Salvendy, G. and Smith, M.J. (Eds), 1981. *Machine Pacing and Occupational Stress*. London: Taylor and Francis.

Sen, T.K. (1987) Participative group techniques. *In* G.Salvendy (Ed.) *Handbook of Human Factors*, New York: Wiley.

Sendapperuma, L., Macdonald, W.A. and Hoffmann, E.R., 1991. P.M.T.S: Are They Applicable to Visual Inspection Tasks? *Proceedings of the 27th Annual Conference of the Ergonomics Society of Australia*, Canberra: Ergonomics Society of Australia.

Shikdar, A.A. and Das, B. (1995) A field study of worker productivity improvements. *Applied Ergonomics*, 26, 1, 21-27.

Shipley, P. (1990) Participation ideology and methodology in ergonomics practice. *In* J.R.Wilson and E.N.Corlett (Eds.) *Evaluation of Human Work*, London: Taylor & Francis.

Siegrist, J. and Peter, R., 1994. Job stressors and coping characteristics in work-related disease: issues of validity. *Work & Stress*, 8, 2, 130-140.

Snook, S.H. and Ciriello, V.M. (1991) The design of manual handling tasks: revised tables for maximum acceptable weights and forces. *Ergonomics*, 34, 1197-1213.

So, C. and Mert Iljin, V. (1990) *Measuring mental workload in an occupational setting*. Research project conducted in partial fulfilment of the requirements of the Graduate Diploma in Ergonomics, La Trobe University.

Spector, P.E. and Jex, S.M. (1991) Relations of job characteristics from multiple data sources with employee affect, absence, turnover intentions, and health. *Journal of Applied Psychology*, 76, 1, 46-53.

Sullivan, B (1995) Personal Communication. Brian Sullivan Management Consultant Pty Ltd, Melbourne.

Toohey, J., 1994. Work Stress. *Worksafe News*, October, 15-18.

Upsdell, T. (1994) *Occupational Burnout, Stress, Mental Workoad and Job Satisfaction among Rehabilitation Counsellors*, Research project conducted in partial fulfilment of the requirements of the Graduate Diploma in Ergonomics, La Trobe University.

University of Michigan (1998) 3D Static Strength Prediction Program (Version 4.0).

Warr, P. (1994) A conceptual framework for the study of work and mental health. *Work and Stress*, 8, 2, 84-97.

Waters, T.R., Putz-Anderson, V., Garg, A. and Fine, L.J. (1993) Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics*, 36, 749-776.

Wilson, J.R. and Corlett, E.N. (Eds) (1995) *Evaluation of Human Work*. (2nd ed.) London:Taylor & Francis.

Worksafe Australia (1993) OWAS Analysis Program (Version 2.2).