WORLD CLASS HEALTH & SAFETY EVENT
Michigan Safety Conference

Ergonomics 101: Developing an Ergonomics Process and Utilizing Job Analysis

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94 Years - Find Your Safety __________!

1

Agenda

- Introduction to Ergonomics
- How Ergonomics became part of the business
- Developing an Ergonomics Process
  - Plant Ergonomics Process
  - Future Program Ergonomics Process
- Utilizing Job Analysis
  - Second-level Ergonomics Analysis
  - Ergonomics Guidelines, Training and Resources
- Other Activities – New Technology
- Summary & Questions

2

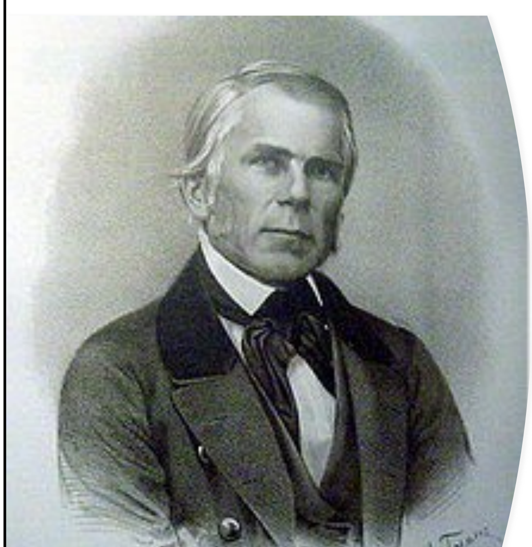
Ergonomics Definition

"Ergonomics is that field of study concerned with the design of environments, processes and products that are suitable for safe and effective worker use."

The UAW-GM Joint Process

...the science of **optimizing** the Design of Product, Equipment, Tools and Work Assignments to **match** the Capabilities and Limitations of the Operators

3



Wojciech Jastrzębowski 1799-1882

Rys ergonomji czyli nauki o pracy, opartej na prawdach poczerpniętych z Nauki Przyrody

The Outline of Ergonomics, i.e. Science of Work, Based on the Truths Taken from the Natural Science (1857).

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4

What ERGONOMICS Is and Is Not: One Way to Look at It

Ergonomics is **NOT** a Health and Safety issue.

Ergonomics is an Engineering issue.

Ergonomics becomes a Health and Safety issue, **only after an injury has occurred**.

In order to avoid these injuries from occurring, the use of Engineering Solutions should be the primary counter measure.

5

5

How Ergonomics Became Part of the Automotive Business

- OSHA fines at assembly plants in the 1980s.
- A *Tri-party Agreement* reached between GM, the UAW and OSHA. The other automotive companies started similar programs through collective bargaining agreements.
- Meatpacking and other industries had their own agreements over those years.
- The agreements stipulated the creation of an ergonomics team at each plant.
- Training and screening tools developed for use in the plants.
- Regular reporting and charting of progress became formalized part of plant and management responsibilities.

OSHA Occupational Safety and Health Administration

UAW

GM

6

Initial Efforts

- The initial stage focused on training the analysts in conducting screening assessments and in making the workforce aware of ergonomics risk factors.
- All jobs at the plants were screened to identify and correct problem jobs.

7

How it Developed

- More sophisticated second level analysis tools were introduced to allow more detailed analysis.
- The program continued to change with the improvement of tools and the changes to the business.
- Today each of the Big Three plants has an ergonomics team consisting of salaried and hourly members.

8

Engineering Developments

- In conjunction with the Tripartite Agreement, ergonomics groups were incorporated into industrial engineering departments.
- Engineers were trained to recognize and eliminate ergonomics stressors
  - A variety of tools and guidelines were developed and incorporated into the engineering and manufacturing processes.
- The process was directed towards the identification, elimination and prevention of Musculoskeletal injury RISK FACTORS.

9

Work-Related Musculoskeletal Disorders: Risk Factors



Primary Risk Factors:

- Excessive ***FORCE***
- ***REPETITION***
- Awkward ***POSTURE***
- ***DURATION***

Secondary Risk Factors:

- Vibration
- Temperature (Cold)
- Impact Stress
- Tactile Feedback
- Soft Tissue Compression

10

Overview of Ergonomics

Two categories of Ergonomics involvement

- **Reactive Ergonomics** – Assessing/correcting problems/risk factors on existing jobs in **plants** (**current programs**).
- **Proactive Ergonomics** – Preventing ergonomics problems/risk factors by intervening with **product and process design** (**future programs**). This includes following applicable standards and best practices and assessing designs for potential risk factors.

11

DEVELOPING AN ERGONOMICS PROCESS:

Plant Ergonomics Process

12

Plant Ergonomics Process (Reactive)

The plant ergonomics process involves:

- Common Medical Management
- Common Processes & Procedures
- Common Training
- Common Ergonomics tools
- Common Issue Tracking

13

Ergonomics Program

Each Plant has an ergonomics team consisting of one salaried and at least one hourly trained ergonomist

– Have the responsibility of assessing, correcting, documenting and reporting out on ergonomics problems at the plant as part of the joint ergonomics process.
– Are put through 72+ hours of required training

14

Ergonomics Program

Three key aspects

1. Minimize physical impact of Ergonomics-related Musculoskeletal disorders – early diagnosis, treatment and follow-up medical care
2. Prevent ergonomic risks – design-in activities
3. Identifying and Reducing / Eliminating ergonomic risks of existing jobs

15

Ergonomics Process

1. Ensure employees are aware of the company Ergonomics Program
   - Ergonomic risk factors
   - Symptoms of ergonomics injuries and illnesses
   - Encourage employees to report potential ergonomics symptoms early

16

Ergonomics Process

2. Identifying and Reducing / Eliminating ergonomic risks of existing jobs
   - Identification
   - Analysis
   - Correction
     - Re-Analysis

17

Ergonomics Process

3. Design-in
   - The joint program is involved in the identification, analysis and correction of new technology, products, and processes
   - This is outlined in the Design Process documents

18

Ergonomics Process

- Identification – identify jobs with potential ergonomic concerns
  - Quick Response Process to quickly communicate issues
  - Injury/Illness data
  - Worker Compensation Data/ Sickness and Accident Data
  - Referrals - Medical Workplace Walkthroughs
- Use a standardized **Checklist** for job assessment

19

Example: Risk Factor Checklist (RFC)

- Tool Used to Analyze Jobs
- The RFC has 5 Sections
  1. Posture
  2. Energy Expenditure
  3. Upper Extremities Right
  4. Upper Extremities Left
  5. Manual Lifting
- Based on RFC findings, a job can be formally “opened” for correction
- Now they use an electronic version that can be partially filled in with videographic captures.
- There are other checklists available from various sources – see references at end of presentation.

20

Ergonomics Analysis & Corrections

- Issues are tracked and reported out to upper management.
- A process was developed to make sure that the issues, resolutions and effectiveness of the corrections were tracked and confirmed.
- Resolutions and corrections were documented and became part of lessons learned.

21

Product and Process Design:

Future Program Ergonomics Process

22

Future Program Ergonomist Duties

- Identify/quantify risk factors with applicable ergonomics guidelines
- Identify, analyze and document issues as arise. Conduct virtual analyses using product math data and Digital Human Models (DHM).
- Communicate ergonomic concerns to responsible engineers
- Work collaboratively with product and manufacturing engineers to develop solutions cross-functionally
- Escalate Issues as appropriate
- Confirm that issues are tracked to resolution

23

Focus Is On Product Design

- Many if not most ergonomics issues in automotive are the result of product design.
- Many ergonomics risks are due to force exertions and clearance (reaches, spacing).
- Components involved include electrical connectors, tabs, clips, grommets, hoses, etc.

24

Future Program Ergonomics Evaluation Tools

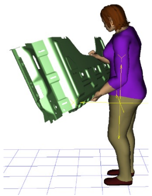
- Ergonomics requirements are provided in specifications.
- First-level **Screening** Tools (ENGINEER) Automotive (GM) Examples:
  - Ergonomics Design Requirements/Assessments [Global]
  - Body-In-White Ergonomics Worksheet [Global] – for operations on the welded car body prior to painting
  - Lift Assist and Tooling Worksheet [Global] – for lift assists
  - Container Worksheet [Global] – for the design of all types of containers from small totes to large racks

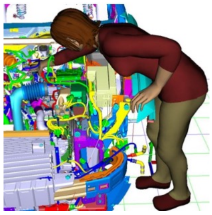
25

Virtual Ergonomics Assessments

✓ Siemens Classic JACK/Process Simulate or other DHM system used for ergonomics assessments
  - Advanced task analysis software that combines math data visualization and ergonomics analysis in the same tool
  - Evaluates operator posture, strength, reach, & manual/visual access

✓ Use of the Digital Human ensures
  - Conformity for ergonomics analysis and assessments around the globe (reach, strength and clearance)





26

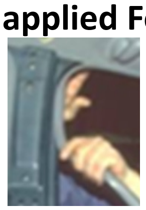
Ergonomics Communications

- Issues, both virtual and physical, are tracked and reported out to the program teams including program leadership on a weekly basis.
- Color-coding is used to communicate issue status and severity.

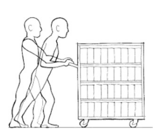
27

Design Ergonomics Requirements
Examples of Risk Factors Assessed

- Repetition/Duration
- Finger/Thumb/Hand applied Force or Torque




- Access for Finger/Thumb and Hand
- Horizontal/Vertical Location/Reach
- Visual Access
- Power Tool Torque Rating/Vibration
- Lifting/Whole Body Pushing/Pulling
- Walking/Carrying



28

UTILIZING JOB ANALYSIS:
JOB ANALYSIS AND ERGONOMICS ASSESSMENT TOOLS

29

Second-Level Ergonomics Analysis

30

Mandatory Program Ergonomics Training/Second Level Tools

Practical Ergonomics Training

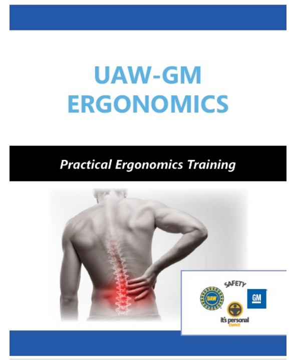
- Includes training on basic ergonomics and record keeping
- PET class is 32 hours

3-D Static Strength Prediction Program (SSPP)

- 20 hour class

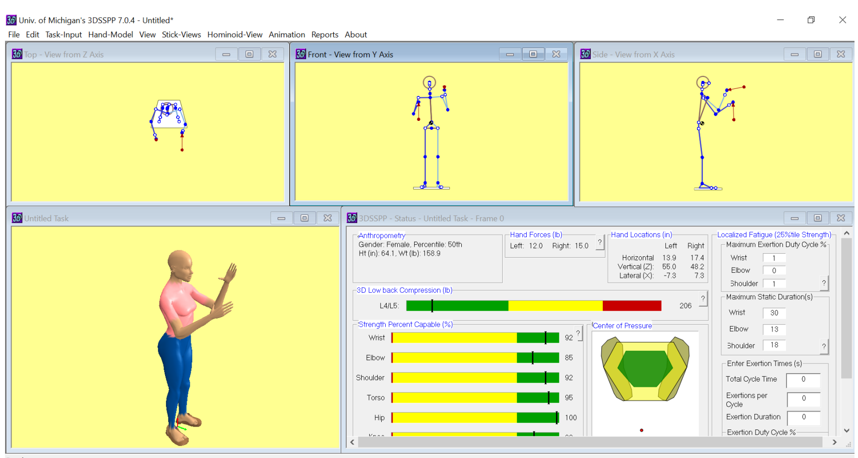
Secondary Analysis Tools – Training common for engineers as well as Plant Ergonomists

- Snook Push/Pull/Carry,
- Energy Expenditure Prediction,
- NIOSH Lifting Equation,
- Ergonomist Statistical Toolbox
- Hand Activity Threshold Limit Value (HAL TLV)
- 20 hours class



31

3D Static Strength Prediction Program



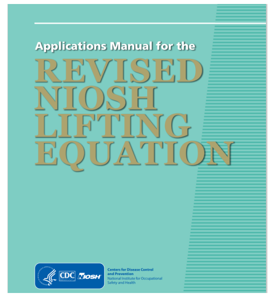
32

NIOSH Lifting Program
Updated 2021

The NIOSH Program is probably the most often used tool for the analysis of lifting tasks.

Both 1981 and 1991 Manual Lifting Guides
H Factor = Horizontal Reach
V Factor = Vertical Distance
D Factor = Distance Traveled
F Factor = Frequency in Lifts per Minute

Added in the 1991 Manual Lifting Guide
A Factor = Asymmetry (Twisting)
C Factor = Coupling



1981: Action Limit (AL) = 90lb X (HF)(VF)(DF)(FF)
1991: RWL = 51lb X (HF)(VF)(DF)(AF)(FF)(CF)

RWL: Recommended Weight limit

Lift Index (LI) = Actual Weight Lifted/RWL

33

'Snook' Tables
Manual Handling Push/Pull/Carry Program

Table 6. Maximum acceptable forces of push for males (kg).

Height‡	Percent§	2·1 m push, one push every 6 s	12 s	1 min	2 min	5 min	30 min	8 h	7·6 m push, one push every 15 s	22 s	1 min	2 min	5 min	30 min	8 h	15·2 m push, one push every 25 s	35 s	1 min	2 min	5 min	30 min	8 h	30·5 m push, one push every 1 min	2 min	5 min	30 min	8 h	45·7 m push, one push every 1 min	2 min	5 min	30 min	8 h	61·0 m push, one push every 2 min	5 min	30 min	8 h
Initial forces¶																																				
144	90	20	22	25	25	26	26	31	14	16	21	21	22	22	26	16	18	19	19	20	21	25	15	16	19	19	24	13	14	16	16	20	12	14	14	18
	75	26	29	32	32	34	34	41	18	20	27	27	28	28	34	21	23	25	25	26	27	32	19	21	25	25	31	16	18	21	21	26	16	18	18	23
	50	32	36	40	40	42	42	51	23	25	33	33	35	35	42	26	29	31	31	33	33	40	24	27	31	31	38	20	23	26	26	33	20	22	22	28
	25	38	43	47	47	50	51	61	27	31	40	40	42	42	51	31	35	37	37	40	40	48	28	32	37	37	46	24	27	32	32	39	23	27	27	34
	10	44	49	55	55	58	58	70	31	35	46	46	48	49	58	36	40	43	43	45	46	55	32	37	42	42	53	28	31	36	36	45	27	31	31	39
95	90	21	24	26	26	28	28	34	16	18	23	23	25	25	30	18	21	22	22	23	24	28	17	19	22	22	27	14	16	19	19	23	14	16	16	20
	75	28	31	34	34	36	36	44	21	23	30	30	32	32	39	24	27	28	28	30	30	36	21	24	28	28	35	18	21	24	24	30	18	21	20	26
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	25	41	46	51	51	54	55	65	31	35	45	45	48	48	58	35	40	42	42	45	45	54	32	36	42	42	52	27	31	36	36	45	27	31	31	38
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Sustained forces*																																				
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‡ Vertical distance from floor to hands (cm).
§ Percentage of industrial population.
¶ The force required to get an object in motion.
* The force required to keep an object in motion.
Italicized values exceed 8 h physiological criteria (see text).

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ARTICLE
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The Liberty Mutual manual materials handling (LM-MMH) equations

Jim R. Potvin[a,b], Vincent M. Ciriello[a], Stover H. Snook[a], Wayne S. Maynard[a] and George E. Brogmus[a]
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34

Hand Activity Level TLV - 2001

ACGIH® TLV® for Hand Activity

Job	Analyst	Date
	Left	Right
Hand Activity Level (HAL) (See scale below)		
Normalized Peak Force (NPF) (See table below)		
Ratio = NPF / (10-HAL)		
Determine Result TLV = 0.78 AL = 0.56	> TLV ☐ AL to TLV ☐ < AL ☐	> TLV ☐ AL to TLV ☐ < AL ☐

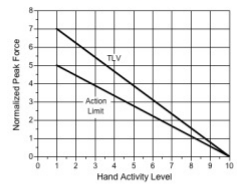
Hand Activity Level Rating

0	2	4	6	8	10
Hands idle most of the time; no regular exertions	Consistent conspicuous long pauses; or very slow motions	Slow steady motion/exertions; frequent brief pauses	Steady motion/ exertion; infrequent pauses	Rapid steady motion/exertions; no regular pauses	Rapid steady motion/ difficulty keeping up or continuous exertion

Estimation of Normalized Peak Force for Hand Forces

%MVC	*Subjective Scale*		*Moore-Garg Observer Scale* (Alternative Method)	*NPF*
	Score	Verbal Anchor		
0	0	Nothing at all		0
5	0.5	Extremely Weak (Just Noticeable)	Barely Noticeable or Relaxed Effort	0.5
10	1	Very Weak		1
20	2	Weak (Light)	Noticeable or Definite Effort	2
30	3	Moderate		3
40	4		Obvious Effort, But Unchanged Facial Expression	4
50	5	Strong (Heavy)		5
60	6		Substantial Effort with Changed Facial Expression	6
70	7	Very Strong		7
80	8			8
90	9		Uses Shoulder or Truck for Force	9
100	10	Extremely Strong (almost maximum)		10

TLV for Hand Activity



American Conference of Governmental Industrial Hygienists (ACGIH). Threshold limit values and biological exposure indices for 2001. Cincinnati: ACGIH, 2001. See www.acgih.org for more information.

35

Revised TLV for Hand Activity Published by ACGIH Feb. 2018

ACGIH® © 2018 **Hand Activity – page 1**

HAND ACTIVITY

TLVs®

Although work-related musculoskeletal disorders can occur in a number of body regions (including the shoulders, neck, low back, and lower extremities), the focus of this TLV is on the hand, wrist, and forearm.

The TLV shown in Figure 1 is based on epidemiological, psychophysical, and biomechanical studies and is intended for jobs performed from four to eight hours per day. The TLV specifically considers average Hand Activity Level (HAL) and Normalized Peak Force (NPF) to represent conditions to which it is believed nearly all workers may be repeatedly exposed without adverse health effects.

HAL is based on the frequency of hand exertions and the duty cycle (distribution of work and recovery periods). HAL can be determined by trained observers based on exertion frequency, rest pauses and speed of motion using the rating scale shown in Figure 2. Only hand exertions greater than 10% of posture specific strength should be considered. HAL can also be calculated based on empirical studies of expert ratings, hand exertion frequency and duty cycle (exertion time/(exertion + rest time) × 100%). HAL can be calculated as:

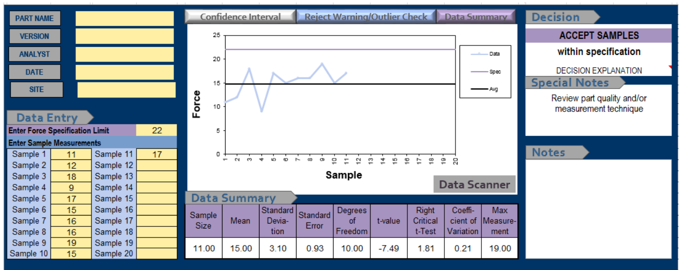
$$\mathrm{HAL} = 6.56 \ln D \left[\frac{F^{1.31}}{1 + 3.18 F^{1.31}} \right]$$

(D = duty cycle [%] and F = hand exertion frequency [exertions/s]) or estimated from Table 1. Calculated HAL values should be rounded to the nearest whole number.

36

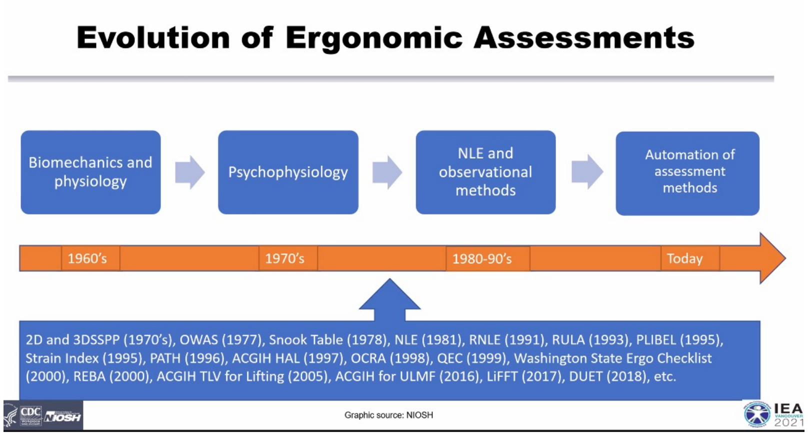
36

Statistical Analysis Tool & Force Measurement



A CLOSER LOOK AT ERGONOMICS ASSESSMENTS AND TOOLS …

How Ergonomics Assessments Have Evolved



- Slide from Jack Lu shown at IEA in 2021.

39

How Ergonomics Assessments Have Evolved

- Assessments have developed based upon the data and techniques available at the time – table look-ups, measurements easily taken in the field with minimal equipment, etc.
- Most ergonomics tools and methods, with a few exceptions, have been essentially 'one-off' in that they assess a very specific condition. Many have been based on 'mono-task' work situations.
- Ergonomics tools, and most ergonomists, have focused almost entirely on ***physical*** risk factors.
- The nature of ***risk*** is not well-understood by many ergonomists and their managers whether in health and safety or in engineering.

40

New Technology – Wearables and Video-Graphics

- Wearables
  - Fitted to the worker/subject and can collect data on speed, acceleration, location and thus on posture and movement of different parts of the body. Force collection wearables have also been introduced.
  - Data can be inputted into biomechanical models and/or ergonomics assessment methods such as Hand Activity TLV and the RNLE.
  - Disadvantages include intrusiveness, time to fit it to the worker, data transmission issues in some workplaces.
- Videographics
  - Utilizes camera, IPad or cell phone to film task – image capture technology and algorithms developed to pull information on posture, speed, etc. from images.
  - Minimally intrusive for the worker and workplace and very quick.
  - As with wearables, data can be inputted into biomechanical models and/or ergonomics assessment methods such as Hand Activity TLV and the RNLE.
  - Disadvantages include capturing all motions and views in the workplace in cluttered and complex work areas.

41

Potential of Wearables and Video-Graphics

- The relatively easy AND accurate collection of data that at one time could only be collected in a laboratory setting has the potential to revolutionize ergonomics assessment tools.
- Assessment tool inputs, such as those for the RNLE, were limited to what an analyst could measure at the job using scales, tape measures, etc.
- More detailed posture, movement, time and acceleration data could allow more advanced inputs to these tools.
- Algorithms to reliably calculate various inputs are still problematic.
- AI and machine learning increasing used with new technologies.
- These technologies will result in the creation of a LOT of data that will have to be processed and communicated.

42

Future Needs and Directions in Ergonomics

- Industry has steadily moved to work situations that are more varied and complex with workers rotating jobs and/or performing more variable work.
- As such, there is growing interest in tools that can assess **long-term or composite risk across multiple and/or mixed exposures to job risk factors**. This is a clear challenge for wearable and videographic-based methods.
- The Variable Lift Index (VLI) and Sequential Lift Index (SLI) extensions of the Revise NIOSH Lift Equation are a step in this direction as are the Fatigue-Failure tools DUET and LiFFT.
- Also interest in assessing jobs in agriculture, construction and warehousing which may present very high variation within a day, week or season.

43

Future Needs and Directions in Ergonomics (Continued)

- In many studies, various **psychosocial factors** have shown a relationship to injury risk, via regression studies and odds ratios, equal to or greater than measures of physical load such as the NIOSH LI or classifications of high physical exertion. This applies to back injury as well as upper extremity MSDs**.**
  - Contribution of Personal and Psychosocial Risk Factors to Overall Injury Risk in General: 30 – 50%
  - Global Burden of Back Injury due to Non-Occupational Risk Factors: 63%
- Overall, we can see the need for ergonomics assessments to become more **personalized** and to integrate more risk factors in addition to the traditional physical risk factors.
- Ergonomics and ergonomists should be more focused on **proactive job design** with engineers and not just on assessing and fixing current jobs.

44

Ergonomics Guidelines, Training and Resources

45

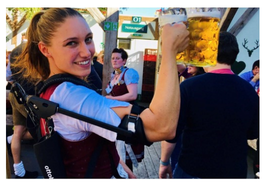
Industry Ergonomics Guidelines & Standard Documents

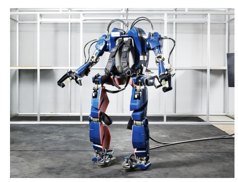
- SAE/USCAR 25 Ergonomics Specification for Electrical Connections
- SME/USCAR 41 Ergonomics Guidelines for Carts & Dollies (Dolly Exchange Systems)
- SME/USCAR 42 Ergonomics Guidelines for Small Lot Delivery Operations
- Analysis and Interpretation Guides for 3D SSPP and Energy Expenditure Prediction Analysis.

46

Other Activities – New Technology Trials

STRONGARM TECH
LEVITATE TECHNOLOGIES, INC.
SARCOS
SUITX
SkelEx
GoX Studio Accuracy wins.
ottobock.
ekso BIONICS
modjoul
laevo exoskelet
COMAU
WYSS INSTITUTE
noonee





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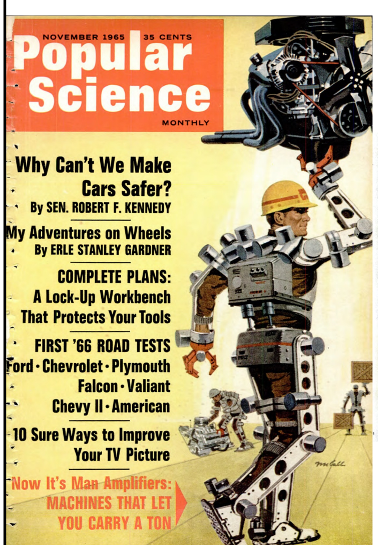
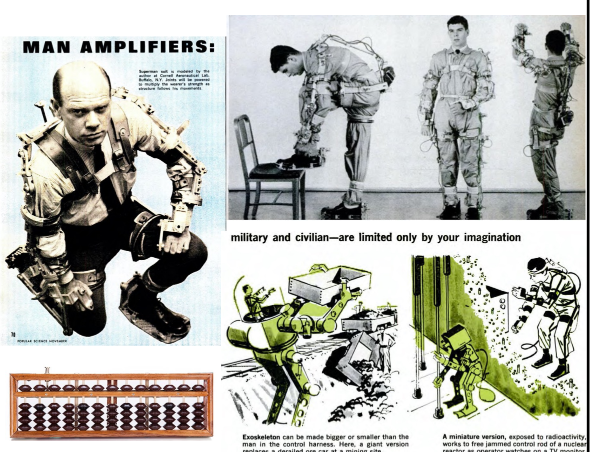


Exoskeleton/Wearable Concepts Have Been Around for Many Years!



48

Summary

- The automotive companies have both **REACTIVE** and **PROACTIVE** ergonomics processes
  - Common proactive and reactive processes and procedures
  - Common training
  - Common tools
  - Common issue tracking

49

Implications for Business

- The function and role of ergonomics needs to be embedded in the business process in order to realize maximum benefit from it.
- The emphasis should not be on "ergonomics fixes."
  - While there may always be some level of existing jobs that need assessment and correction, the emphasis should move towards ***prevention.***
  - Preventing ergonomics stressors from becoming risk factors involves identifying them and designing them out in the design phase of the product and process

50

Steps in Introducing an Ergonomics Program

- Understand the nature and magnitude of your problem (illness/injury, etc.).
- Management at all levels must be committed and must lead the process.
- Define your goals – short term and long term, and be realistic.
- Create an ergonomics committee appropriate for your organization.
- Assign specific responsibilities.

51

Steps in Introducing an Ergonomics Program

- Ensure that the necessary resources are allocated.
  - Plan for the necessary training – awareness, basic, advanced;
  - Arrange for the necessary communication links – report outs, lines of communication, etc.;
  - Must have a holistic view of costs involved for the company overall – understand the cost of injuries and the burden on the company;
  - Union and management resources need to be planned for.

52

Steps in Introducing an Ergonomics Program

- Decide on tools, methods, guidelines and references.
- Stay connected with the wider world of ergonomics – associations, universities, websites, seminars, conferences, etc.

53

References and Resources

- Washington State Ergonomics Risk Checklists: mailto:https://www.msdprevention.com/RACE/risk-assessment
- IEA MSD Risk Assessment Tools: https://iea.cc/about/ergonomics-in-practice/tools-for-assessing-and-implementing-hfe-in-the-workplace/

54

References and Resources

- AIHA/NIOSH NORA MSD Council Ergonomic Assessment Toolkit: https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/ERGOVG-Toolkit_rev2011.pdf
- Information on ISO Ergonomics Standards: mailto:https://www.hfes.org/Publications/Technical-Standards

55

QUESTIONS/DISCUSSION

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56