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Physical Load at film Wrapping of pallets

## '4 finger method' versus 'Lite Wrapper XT®'





Jaap Westerink, MSc. Eur.Erg.



# GOAL



Objective measurement comparing classic manual and new Lite Wrapper XT® wrapping method of manual film wrapping of pallets

Ergo-Design – Industrial Engineering B.V<sup>1</sup> is asked to assess the new 'Lite Wrapper XT® ' with regard to physical load compared to the classic '4 finger method' of manual wrapping (two fingers at each end of the film core).

**Remark:** Classic '4 finger method' is in further report tekst also referred to as 'Classic Manual wrapping' or 'Manual wrapping'.

<sup>1</sup>ED has ample experience is assessments of work situations for various industries. Some references: are DAF trucks, Scania, BOSCH Nefit, BOSCH VDT, Philips, Mars Masterfoods.







Situation 1: Classic Manual wrapping method Situation 2: New wrapping method with the Lite Wrapper XT®

#### Data

For both situations:

- Comparable wrapping film rolls are used
- Comparable wrapping tasks are performed
- Same test person is used (experienced wrapper)
- Pallet size 800\*1200 mm
- Height 1750 mm incl. pallet

#### Measures:

- Force measurement with 'FEF 200' for film push forces on palletcorner
- Peakforce measurement with 'FEF 200' for film peakforces on palletcorner
- Peakforce measurement with 'Mecmesin Force Gage' for film pull force
- Video-recordings of wrapping pallet load

#### Analysis Physical Load

- Posture, force and intensity assessment conform EAWS<sup>1</sup>
- Expert view (Wijnand Tromp MSc. Eur.Erg. and Jaap Westerink MSc. Eur. Erg.)

<sup>1</sup> EAWS = Ergonomic Assessment Worksheet. A European used, substantiated and well-known method for assessment of (combined) physical loads.







Figure 1: Classic manual method 20 Cast Hipack meas. 1 20 Cast Hipack meas. 2 PS 12 my TPC meas. 1 PS 12 my TPC meas. 2 Figure 2: Lite Wrapper XT® method PS X-lite Litewrapper meas. 1 PS X-lite Litewrapper meas. 2



RESULTS

#### FORCE MEASUREMENTS

ED Force gage and FEF measurements				AVG	CF
Height [cm] approx.	150	150	150	150	
20 Cast Hipack peak pull force (N)	116,8	92,5	101,3	103,53	0,33
20 Cast Hipack peak push force FEF (daN)	3,9	3,4	2,9	3,40	
PS 12 my TPC peak pull force (N)	105,1	84,9	90,5	93,50	0,40
PS 12 my TPC peak push force FEF (daN)	4,4	3,4	3,5	3,77	
PS X-lite Litewrapper peak pull force (N)	41,5	44,4	47,3	44,40	0,66
PS X-lite Litewrapper peak push force FEF (daN)	2,7	3,3	2,8	2,93	

#### remarks

- Measured values are peakforces (see also app.2)
- Force pattern varies in time during wrapping
- Force pattern at Lite Wrapper XT® has less variation due to evenly pre-stretching of film
- Various types of film are tested (see table)
- $1 \, daN = 10 \, N$

#### conclusions

- At classic wrapping the corner push force is at average 37% of peak pull force
- At Lite Wrapper XT® the corner push force is at average 66% of peak pull force

#### recommendation

- Force measurement results become more representative if :
  - measured in time
  - multiple test persons would be used

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#### FORCE MEASUREMENTS - FEF push force palletcorner (kg) versus height (see app.3)



#### remarks

- Test person has had short instruction how to handle Lite Wrapper XT®.
- Test person is experienced in wrapping pallets and got no instruction on that part
- At manual wrapping starting point is a lower end pallet corner where film is tied
- At Lite Wrapper XT® top corner is the starting point where film is fixed between boxes, with one free hand.





### FORCE MEASUREMENTS - FEF push force palletcorner (kg) versus height

#### conclusions

- Classic Manual wrapped film has a significant lower palletcorner push force
- Differences are largest on the lower end of the pallet load (up to a factor 5) and smallest at shoulderheight (up to factor 2).







#### **EAWS**

The EAWS<sup>1</sup> method is used to compare physical load of both situations. Following remarks should be made:

- Both categories for **Posture** and **Action Force** are judged as relevant and applied.
- Scoring is made for the task of 'film wrapping of a pallet'
- Frequency and other tasks are not assessed while they are unknown.
- Scoring is performed separately per category so differences appear clearly between methods
- Results may be compared per category but should not be summed.
- A higher score means a higher physical load.
- Absolute score values are not representative as long as no day-load score is calculated.
- To compare Action Forces two handed (classic) and single handed (Lite Wrapper XT®) should be distinguished.

<sup>1</sup> EAWS = Ergonomic Assessment Worksheet. A by the German 'Institut für Arbeitswissenschaft in Darmstadt' developed method for the assessment of physical loads. The method is used Europe wide and is a carefull substantiated and proven method for the assessment of (combined) physical loads..





#### **EAWS**

*EAWS method and scores are based on following international standards :* 





RESULTS

ERGO DESIGN

#### EAWS – Posture score Manual wrapping EAWS – Posture score Lite Wrapper XT®

			Ergono	mic	: As	ses	ssm	ent	Wo	orks	she	et \	/1.3	.3			
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(in	cl. loads	s of <3 kg			9962	SPORTES		DU BALO	YOAN U.S					CRAPTICAL DE LA COMPANY	As	symmetry eff	ects
an	d action	forces of 30-40 N)				Eval	uatio	n of	static	post	tures				Trunk	Lateral	Far Reach
				and	/or hi	igh fr	eque	nt m	oven	ents	of tr	unk/a	arms	10	Rotation 1	Bending 1)	2)
Sta	atic post	tures: > 4sec												un	N	X	A
Hie	ah frequ	ency movements: 2		6	uratio	n [sec.	/min]	dun	ation o	f poste	ure(s)	x 60		fof	XD	177	
tru	nk bend	ling or 10 arm lifting >		-		-			cj	rcle un	ne		-	ī	10	1 1	11
60	* per mi	n	1061	5	175	1 10	15	20	97	22	50	: 67	1 82	es	0.5 0.2	0.5 0.7	nt our
3			[sec/min]	3	4.5	6	9	12	16	20	30	40	50		Intensity	Interactive	Intensitive
10			[min/8h]	24	36	48	72	96	130	160	240	320	400		Duration	Duration	Duration
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2	-9	Standing, no body support (fr	or other	0,7	1	1,5	2	3	4	6	8	11	13				1.
3	93	Bent forward (20-60°)		2	3	(5	7)	9,5	12	18	23	32	40	6			
0	1	with suitable support		1,3	2.	3,5	5	6,6	8	12	15	20	25	0			
	0	Strongly bent forward (>60°)		3,3	5	8,5	12	17	21(	30	38	51	63	29	13		
4	NE	with suitable support		2	3	5	7	9,5	12	18	123	31	38	32	3		
5	×1	Upright with elbow at / above level	e shoulder	3,3	5	8,5	12	17	21(	30	38	51	63	28	1		
6	ý	Upright with hands above he	ad level	5,3	8	14	19	26	33	47	60	80	100				
Sit	ting		CLAR STORY							Contract of	1	1		to the second second			Contraction in the local division of the loc
7	1	Upright with back support slightly bent forward or back	ward	0	0	0	0	0	0	0,5	1	1,5	2				
8	2	Upright no back support (for restrict see Extra Points)	other	0	0	0,5	1	1,5	2	3	4	5,5	7				1
9	3	Bent forward		0.7	1	1.5	2	3	4	6	8	11	13				
	11											L	10				
10	Ă	Elbow at / above shoulder let	vel	2,7	4	7	10	13	16	23	30	40	50				
11	H	Hands above head level		4	6	10	14	20	25	35	45	60	75				
Кл	eeling	or crouching	a second	1	The K	12370		1.0	12.8		1000	No.	all set	al total be	1		Halapara
12	2.2	Upright		3,3	5	7	9	12	15	21	27	36	45				1
13	22	Bent forward		4	6	10	14	20	25	35	45	60	75				
14	33	Elbow at / above shoulder let	vel	6	9	16	23	33	43	62	80	108	135		1		15614
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		Postures = $\sum$ lines 1 -	16				(	a)	-			(	b)	=	C	9	

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(ind and Sta Hig	nd action forces of 30-40 N) tatic postures: > 4sec igh frequency movements: 2 igh kending or: 10 arm lifting >				Evaluation of static postures and/or high frequent movements of trunk/arms Duration (sec/min)								Sum of	As Trunk Rotation 1	Lateral Bending 1)	Far Re 2)	
trur 60°	nk bend ' per mi	ding or 10 arm lifting > in	[%] [sec/min]	5 3	7.5	10	15.9	20	27	33 20	50 30	67 40	83 50	lines	int dur 0-5 0-3 Intensity x	int dur 0-5 0-3 Intensity x	int o 0-5 0 Intensit
Sta	nding	(and walking)	[[min/8h]	24	: 36	: 48	1 /2	1.96	130	160	240	320	400		Durabon	Durason	Dura
1	- Ja	Standing & walking in alter standing with support	ation,	0	0	0	0	0,5	1	1	1	1,5	2	1			
2	Ĵ	Standing, no body support restrict. see Extra Points)	(for other	0,7	1	1,5	2	3	4	6	8	11	13			I.	
3	3 -	Bent forward (20-60°) with suitable support		2	3	5 3.5	<b>7</b>	9,5 6.5	(12	18	23	32	40 25	15			
4	3	Strongly bent forward (>60 with suitable support	')	3,3	5 3	8,5	12	17	21 12	30 18	38 23	51	63 38		1		
5	Å	Upright with elbow at / abor level	/e shoulder	3,3	5	8,5	12	17	21	30	38	51	63	15		I,	
6	X	Upright with hands above h	ead level	5,3	8	14	19	26	33	47	60	80	100		I		
Sitt	ing		WE HALLING	0.54	3000	12100		903		12.00	2019	14.00		110100	120 1.111		-
7	Å	Upright with back support slightly bent forward or bac	kward	0	0	0	0	0	0	0,5	1	1,5	2				
8	Å	Upright no back support (fo restrict. see Extra Points)	r other	0	0	0,5	1	1,5	2	3	4	5,5	7				
9	R	Bent forward		0,7	1	1,5	2	3	4	6	8	11	13				1
0	ĥ	Elbow at / above shoulder l	evel	2,7	4	7	10	13	16	23	30	40	50				
1	ĥ	Hands above head level		4	6	10	14	20	25	35	45	60	75				
ne	eling o	or crouching	14535555	1000			1		100		176	100	-	CONCERNING IN	1000	1000	599
2	11	Upright		3,3	5	7	9	12	15	21	27	36	45		1	1	4
3	22	Bent forward		4	6	10	14	20	25	35	45	60	75			1	
4	22	Elbow at / above shoulder le	evel	6	9	16	23	33	43	62	80	108	135				
5	20	(Lying on back, breast or sid above head	de) arms	6	9	15	21	29	37	53	68	91	113				
5	AN	Climbing		6,7	10	22	33	50	66								
1	runk int	0 1 3 slightly medium strongl <10° 15° 25° 0 15 25	5 / extreme >30*	2)	Reach	0 close	,	1 60%		3 80%		5 arm stretch	ed		2 (max=15)	Σ (max=15)	E (mix.
	dur	never 4 sec 10 sec	13 sec	-	dur	neve	r	4 set	,	1,5 10 se	c	13 56	c		2 (max, =	40)	





#### EAWS – Posture score

#### remarks

- Score is built up out of various posture components 'back, at/above shoulder, torsion'
- For video-analysis values see also appendix 1 and pictures below.

#### conclusions

- Posture is the dominant factor in the EAWS score
- The Lite Wrapper XT® scores significantly better than manual wrapping 31 versus 69 points on posture score
- Lower part of circulating the pallet at 'Manual wrapping' is performed walking backwards

#### recopmmendation

- Wrapping with the Lite Wrapper XT® up or above schoulder level should be prevented because of the weight to be carried. A redesign of the handle could improve this aspect.





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#### EAWS – Action Forces score Manual



#### **EAWS – Action Forces score Lite Wrapper XT®**



Action Force: standing whole body pull				
	avg classics	20 cast Hipa	PS12 my TPC	PS X light
P40 (N)	260	260	260	260
two hands / one hand	100%	100%	100%	60%
(N)	260	260	260	156
peak force (N)	99	104	94	44
avg force (N) 66,6% / 75%	65	69	62	33
intensity	0,25	0,26	0,24	0,21
intensity factor	3,1	3,5	2,6	1,6
duration	75%	75%	75%	75%
duration factor	8,5	8,5	8,5	8,5
EAWS Action Force score	26,1	29,9	22,2	13,9







#### **EAWS – Action Force score**

#### remarks

- Measured peak-forces have a larger spread at 'Manual' than with 'Lite Wrapper XT®'
- Assumption:
  - Average values pull forces at 'Manual wrapping' = 66% of peak value
  - Average value pull forces at Lite-wrapper XT®' = 75% of peak value because of a smoother built up.
- Allowable value for single handed pulling is 60% of two handed value
- Score is determined by intensity x duration
- For duration 75% of task time is assumed for actual wrapping (duration value 8,5)

#### conclusion

- Action Force scores are significantly lower than the Posture scores
- Action Force scores are less discriminating than Posture scores 14 for 'Lite Wrapper XT®' versus 26 for 'Manual'.
- Single handed operation is relatively scoring higher on physical load.

#### recommendation

- Design :
  - Single handed use of the Lite Wrapper XT® at low height results in a torque force that tilts the device (see photo on page12), or puts extra stress on the wrist muscles. Redesign of handle and two handed operation can improve this effect substantially.
  - Single handed operating the Lite Wrapper XT® above schoulder height is difficult. Redesign and two handed control may offer improvement.

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# DESIGN CONCLUSIONS

**Note:** The performed research has been practically oriented and limited in setup. Therefore the approach is not scientifically representative. Nevertheless some relevant conclusions can be drawn based on the results.

The Lite Wrapper XT® offers clearly advantages over the Classic Manual way of wrapping. A comparison at **task** level with described measuring and assessment methods learns us:

- a. EAWS Posture score is dominant and reduces significantly, with more than 50%:
  - No longer working in strongly bent postures
  - Simple wrapping up to shoulder height
  - Less trunk torsion
  - *Lite Wrapper XT® allows double duration to equal Classic wrapping score.*
- b. Fulltime function execution of Classic Manual wrapping task should be avoided based on high EAWS score that is severely 'red'. Therefore there is a high risk on physical overload and actions are required to prevent this.
- c. De EAWS Action Force score shows a limited contribution to the total physical load. Also here the Lite Wrapper XT® scores better than Classic Manual wrapping even with single handed operation (increases score).
- d. With the Lite Wrapper XT® it is possible to walk more forward oriented in contradiction to the lower circulations at Classic Manual wrapping. In general this is experienced as more comfortable and reduces physical load.
- e. The pre-stretching of film by the Lite Wrapper XT® makes it possible to apply a pull force more evenly. That means lower pull peak forces are required and a more constant wrapping push force is applied on pallet load. Applied wraps were up to 2 to 5x 'tighter' with the Lite Wrapper XT®.
- f. Improved posture and more evenly pulling during wrapping result in a lower energy consumption which allows a substantial longer persevering time.

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#### research

- To substantiate results in a more profound way it is recommended to:
  - a. Measure pulling force course in time
  - b. Compare Classic Manual wrapping and Lite Wrapper XT® for similar film types directly
  - c. For statistical stable results repeat experiments with multiple test persons and high spread values more times.

#### design

- The Lite Wrapper XT® design is a big step forward in relation to the Classic 4-finger method of Manual wrapping. Still on details improvements are possible. Following design change suggestions are recommended:
  - a. Single handed use of the Lite Wrapper XT® at low height results in a torque force that tilts the device (see photo on page12), or puts extra stress on the wrist muscles. Handle redesign combined with two handed operation can improve this effect substantially.
  - b. Single handed operating the Lite Wrapper XT® above schoulder height is difficult based on physical load. Redesign of handle and two handed control may offer improvement.

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#### ERGO DESIGN

## APPENDIX 1: EAWS - Video- analysis Posture score



hand		sec	level	back flex	back rot	shoulder	remark
V230	8x	15	1	>60	10		start
	-	23	1	>60	10		2nd round
		30	2	~60	10		
		41	3	20-60	5		
		49	4	<20	-		
		59	5	~0		@shoulder	
	1.03	63	55	-		>shoulder	not above head
	1:03	67	5,5			shoulder	not above nead
	1.07	78	6			shoulder	
	1.28	88	Ű			shourder	finish
	wrantime	72					mish
	widptille	75					
hand		500	امريما	back flox	back rot	choulder	romark
1/221	87	900	10101	>60	10	SHOULDEL	ctart
V231	0.	16	1	>60	10		2nd round
		22	2	~60	10		21101100110
		23	2	20.60	10		
		32	3	<20-00	5		
	+	42	4	~0		@shoulder	
	+	50	5	0		eshoulder	
	1.00	58	6			shoulder	
	1:06	66	6		<u> </u>	>snoulder	finish
	1:12	72					TINISN
	wraptime	64					
	-						
hand	_	sec	level	back flex	back rot	shoulder	remark
V232	7x	12	1	>60	10		start
		20	1	>60	10		2nd round
		28	2	~60	10		
	_	35	3	20-60	5		
	_	40	3,5	<20			
		47	4,5	~0		@shoulder	
		52	5			>shoulder	
	_	59	6			>shoulder	
	1:07	67					finish
	wraptime	55					
tool		sec	level	back flex	back rot	shoulder	remark
V237	7x	17	6			<shoulder< td=""><td>start</td></shoulder<>	start
		22	6			>shoulder	
		24	6			@shoulder	2nd round
		32	5			<shoulder< td=""><td></td></shoulder<>	
		39	4				
		52	3				
		56	2,5	~20	5		
		59	2	20-60	5		
	1:08	68	1	20-60	5		
	1:17	67					finish
	wraptime	50					
tool		sec	level	back flex	back rot	shoulder	remark
V238		7	6			@shoulder	start
		10	6			>shoulder	
	1	12	6		1	@shoulder	2nd round
		20	5			<shoulder< td=""><td></td></shoulder<>	
	1	27	4		<u> </u>		
	1	35		~20	5		
	1		2	20-60	5		
	+	43	1	20-60	5		
	1.02	23	1	20-00	5		finich
	1.02	02					
	maphille						

hand	V230	V231	V232	avg		task	day
back>60	26	24	23	24,3		38%	7,4%
back 20-60	8	10	5	7,7		12%	2,3%
back<20	39	30	27	32,0	298,0	18%	84,1%
check	73	64	55	64,0			
back rot 10	26	24	23	24,3		38%	7,4%
back rot 5	8	10	5	7,7		12%	2,3%
>shoulder	19	22	20	20,3		32%	6,2%

tool	V237	V238	avg		task
back>60					
back 20-60	11	27	19,0		30%
back<20	39	28	33,5	311,0	34%
check	50	55	52,5		
back rot 10					
back rot 5	11	27	19,0		30%
>shoulder	10	13	11,5		18%

# ERGO APPENDIX 2: EAWS - Action Force score

### stretch business by

#### Force Measurements

ED Force gage and FEF measurements				AVG	CF
Height [cm] approx.	150	150	150	150	
20 Cast Hipack peak pull force (N)	116,8	92,5	101,3	103,53	0,33
20 Cast Hipack peak push force FEF (daN)	3,9	3,4	2,9	3,40	
PS 12 my TPC peak pull force (N)	105,1	84,9	90,5	93,50	0,40
PS 12 my TPC peak push force FEF (daN)	4,4	3,4	3,5	3,77	
PS X-lite Litewrapper peak pull force (N)	41,5	44,4	47,3	44,40	0,66
PS X-lite Litewrapper peak push force FEF (daN)	2,7	3,3	2,8	2,93	

#### **EAWS calculation Action force scores**

Action Force: standing whole body pull				
	avg classics	20 cast Hipa	PS12 my TPC	PS X light
P40 (N)	260	260	260	260
two hands / one hand	100%	100%	100%	60%
(N)	260	260	260	156
peak force (N)	99	104	94	44
avg force (N) 66,6% / 75%	65	69	62	33
intensity	0,25	0,26	0,24	0,21
intensity factor	3,1	3,5	2,6	1,6
duration	75%	75%	75%	75%
duration factor	8,5	8,5	8,5	8,5
EAWS Action Force score	26,1	29,9	22,2	13,9

## ERGO APPENDIX 3: FEF - Measurements



#### **Push Forces**

Values in daN (1 daN = 10N)																
Height [cm]	157,5	142,5	137,5	122,5	117,5	102,5	97,5	82,5	77,5	62,5	57,5	42,5	37,5	22,5	17,5	2,5
20 Cast Hipack meting 1	2,047	1,794	2,986	4,194	2,651	0,644	0,878	1,008	0,776	0,634	1,069	1,183	0,721	0,786	1,857	0,461
20 Cast Hipack meting 2	1,378	1,098	2,059	2,997	2,220	0,543	0,913	1,111	0,462	0,521	1,224	1,358	0,726	0,754	1,780	0,409
PS 12 my TPC meting 1	0,951	1,098	2,694	3,286	0,183	0,215	0,423	0,335	0,756	1,077	0,514	0,693	0,793	0,780	1,297	0,276
PS 12 my TPC meting 2	0,704	0,926	2,015	2,827	1,380	0,352	0,545	0,754	0,474	0,530	0,991	0,684	1,282	0,696	1,278	0,347
PS X-lite Litewrapper meting 1	2,116	2,602	4,783	5,310	2,912	1,347	1,885	2,929	3,206	3,681	4,795	4,502	5,702	3,087	2,578	0,322
PS X-lite Litewrapper meting 2	3,112	2,422	5,042	3,888	1,985	1,089	2,940	2,083	2,502	3,522	3,985	4,711	6,013	3,204	2,658	0,077



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