Anthropometric Compatibility of Driver's Post on Agricultural Tractor Cabs: a Survey on Medium-High Power Tractors

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Introduction: antropometry

A BRANCH OF ERGONOMICS

The study concerned with the measurements of the proportions, size, and weight of the human body

ANTROPOMETRY AND DESIGN

The design of any product involved with the work (and life) environment needs of the information provided by anthropometry
Introduction: anthropometry

• The UNI EN ISO 7250:2010 “Basic human body measurements for technological design” gives a description of anthropometric measurement that can be used as a reference for comparison of groups of people.
• The ergonomics can use this standard to define groups of population and to apply their knowledge to project the geometries of the working and living places of people.

• Generally the dimensions of a working place are projected based on the population dimensions between the 2,5 and 97,5 percentile
In their most comfortable versions the driver’s seats have:

- base large enough and horizontal on the resting points of the ischium (the lower pelvis bone), with a light descending gradient and a length inferior to the thigh (femoral arteries are not compressed and the leg can move freely);
- lower back support adjustable in height and convexity to anatomically support the lower vertebrae (subject to discopathy);
- adjustable inclination of the back for a better support of the trunk;
- arm rests for a better support of the arms;
Characteristics of the driver seat - 2

• a 20° rotation angle in both directions to facilitate entry and exit and observation of rear machinery;

• regulation in height and position (back/forward) to adapt the distance from the commands to the typical dimensions of the driver and to facilitate a comfortable position for both feet on the cabin floor;

• vertical suspension to reduce vibrations made by the machinery and adjustable to the weight of the individual;

• horizontal suspension to reduce horizontal impulses, felt as blows to the back (can generally be turned on or off on command);

• upholstery that allows for perspiration.
The disposition of the commands
has to be rationally studied based on:

- the anthropometric working radius (arms and legs);
- the possibility of easy movements with the hands or the feet;
- easy visibility based on sight angle and easy movement of the head;
- the easy recognition of all the commands to use the machine.
Risks due to improper design of the driver's post

- crushing (overturning)
- crashes with the walls and internal devices
- accidental applying of the commands
- incorrect posture
- discomfort
The research is focused on experimental analysis of the inner dimensions of tractor cabin.

The main goal is to verify the respect of “the least overall dimensions” of the driver (according to EN ISO 3411 standard) calculated on the biggest driver size.

It corresponds to the inner surface of the cabin with no visible deformation.

The experimentation has been carried out on 28 new generation tractors differently dimensioned.

The results have been then compared to verify the least overall dimensions inside the cabin.
Materials and Methods

- SIP instrument
- Form for data transcription (UNI EN ISO 5353)
- Muslin cloth
- Measuring tape
- 10 kg weights
- Bubble levels

Anthropometric Compatibility of Driver's Post on Agricultural Tractor Cabs: a Survey on Medium-High Power Tractors
Technical standard

UNI EN ISO 5353:2000

Earth-moving machinery, and tractors and machinery for agriculture and forestry (Seat Index Point)

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The Seat Index Point (S.I.P.) is a fixed point located inside the cab, determined with the help of a special “instrument for the determination of the S.I.P.”

The Seat Index Point (S.I.P.) is defined by the intersection of the horizontal straight line passing through the two holes on the upper part of the instrument with the vertical straight line passing through the hole situated in the centre of the lower part of the instrument.

The point becomes visible and is the main reference in the measurement of parameters defined by the EN ISO 3411:2007.
Materials and methods: the seat set up

1. To regulate the seat in the median position
2. To make sit a person of 75±10kg, two times for 1 min
3. To leave the seat without load for at least 5 min
4. To cover the seat with a muslin cloth
5. To place the instrument on the center of the seat
6. To add masses to increase the total mass from 6±1kg to 26±1kg
7. To make adhere the instrument to the back and to incline it with oscillations on the two sides
8. To add other masses to increase the total mass from 26±1kg to 65±1kg
9. To proceed with the measurements
Anthropometric Compatibility of Driver's Post on Agricultural Tractor Cabs: a Survey on Medium-High Power Tractors
Technical standard

UNI EN ISO 3411:2007

Earth-moving machinery -- Physical dimensions of operators and minimum operator space envelope

Anthropometric Compatibility of Driver's Post on Agricultural Tractor Cabs: a Survey on Medium-High Power Tractors
ISO 3411:2007 standard: measured parameters

- **R 1**: Distance between the S.I.P. and enclosure ceiling in transverse plane
ISO 3411:2007 standard: measured parameters

- **R 2**: Radius at intersection between the internal walls of the cabin with each other and with ceiling
ISO 3411:2007 standard: measured parameters

- **R3**: Distance towards rear
ISO 3411:2007 standard: measured parameters

- **L1**: Horizontal distance between SIP and enclosure in which R1 is to be maintained
ISO 3411:2007 standard: measured parameters

- $h_1$: Vertical distance between SIP and lower end of upper side walls of the cabin. The standard establishes a maximum value of 150 mm.
ISO 3411:2007 standard: measured parameters

- $h_2$: vertical distance between SIP and lower end of upper back wall of enclosure
ISO 3411:2007 standard: measured parameters

- **W**: Width within space for legs
ISO 3411:2007 standard: measured parameters

- C1: clearance for forearm/hand within upper side areas of enclosure
ISO 3411:2007 standard: measured parameters

- **C2**: clearance between enclosure and operator’s shoe working pedal or foot control in any position
Tests on tractors - 1

1. Carraro 7800 T GF
2. CAT Challenger MT765 C
3. Class Ares 617 ATZ
4. Class Arion 510
5. Class Arion 610
6. Deutz- Fahr Agrofarm 430
7. Fendt Vario 415
8. Fendt Vario Farmer 412
9. John Deere 5090 GF
10. John Deere 5090 R
11. John Deere 5090 G
12. John Deere 6630
13. John Deere 6930
14. John Deere 8310 T
15. Kioti EX 50

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16. Kioti DK 55/C
17. Lamborghini 880 F Plus
18. Lamborghini R 6 165.7
19. Landini Vision 105
20. Massey Ferguson 5455
21. Massey Ferguson 6260
22. Massey Ferguson 6480
23. New Holland CSX 7040
24. New Holland T 4050 F
25. New Holland T 5050
26. New Holland T 5060
27. New Holland T 5070
28. New Holland TK 4060
Results and discussion - 1

Summary plot for each tractor

The green column represents the measured values, while the red one the values defined by the EN ISO 3411 standard.
Results and discussion - 2

Summary plot for each analyzed parameter

Each table shows the limit set by standard for the parameter

Anthropometric Compatibility of Driver's Post on Agricultural Tractor Cabs: a Survey on Medium-High Power Tractors
## Results and discussion

Overview of the measured parameters and comparison with the standard limits (red line)

<table>
<thead>
<tr>
<th>Model</th>
<th>Parameter</th>
<th>Value</th>
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<tbody>
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**R1**

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Results and discussion

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Results and discussion - 3

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Results and discussion

Overview of the measured parameters and comparison with the standard limits (red line)
Parameters more frequently not respected

- **h2**: vertical distance between the SIP and the lower extremities of the upper rear wall of the cabin.
  \[ h2 \geq 280 \text{ mm} \]
  **97% of tractors don’t respect the standard (Δ > 52%)**

- **h1**: vertical distance between the SIP and the lower extremities of the upper side walls of the cabin.
  \[ h1 \leq 150 \text{ mm} \]
  **53% out standard (Δ > 25%)**

- **R1**: distance between the S.I.P. and the cabin ceiling in the transverse plane. The minimum value is 1000 mm for operators without protective helmet, on seats with suspension and adjustment.
  **43% out standard (Δ > 12%)**
Parameters less frequently not respected

- **C2**: clearance between enclosure and operator’s shoe working pedal (≥ 30 mm)
- **W**: width within space for legs (≥ 560 mm)

For both parameters only 7% of tractors were non-conforming
Conclusions

PARAMETER h2

97% non conforming to the standard
Average difference > 52%

The measured values are higher than the standard recommended one, but this is useful in increasing the view towards the bottom rear of the vehicle, freeing the prospect to the tools driven by the tractor.

A violation which brings benefits to the tractor driver!!!
PARAMETER h1

53% non conforming
Difference >25% (on average)

Even in the case of h1 is to assess the actual value of the violation. The value of non-standard parameter is often due to the presence on the right side of the cab of the management console of the machine tools and electronics. Physically, this console is often adherent to the driver's seat and is therefore in a location convenient to the operator.
Conclusions - 3

PARAMETER R1

43% non conforming difference >12% (on average)

Tractors with a R1 parameter out of the standard usually lodge at the top or side of the ceiling the air conditioning vents…

… or other control devices

Components that never really interfere with the visibility or with any operator's head movements.
Conclusions - 4

• The "violations" found for the parameters of tested cabs have to be evaluated taking into account the real way of use of tractors. You can basically say that while not adhering to the standard EN ISO 3411:2007, the parameters don’t represent real obstacles or limitations, but often provide benefits to the operator.

• Not being a legally binding standard, the manufacturers are not required to fully comply with EN ISO 3411:2007

• The results obtained show that, although smaller, the latest generation tractor cabs are:
  - ergonomic
  - more adaptable to the human dimensions
  - equipped with easily accessible controls
  - equipped with easily recognizable commands
Comparing the data already obtained by the authors in a previous paper, using the standard 3411:2000 for older generation tractors, with the new results obtained from this research, it can be observed that in the recent time there is a widespread adherence to the sizing requirements of the standard EN ISO 3411:2007.

The parameters are often oversize, but this, more than a mere violation of the rules, is often to be understood as adaptations and / or adjustments consistent with commercial and constructive compromises of vehicle manufacturers.
Considerations

• Manufacturers should make products commercially attractive with a good level of innovation and good productivity to remain competitive in the market.

• Calling for greater investment in ergonomic design.
NEED FOR A GREATER RESPECT OF GUIDELINES CONTAINED IN EN ISO 3411:2007 STANDARD
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