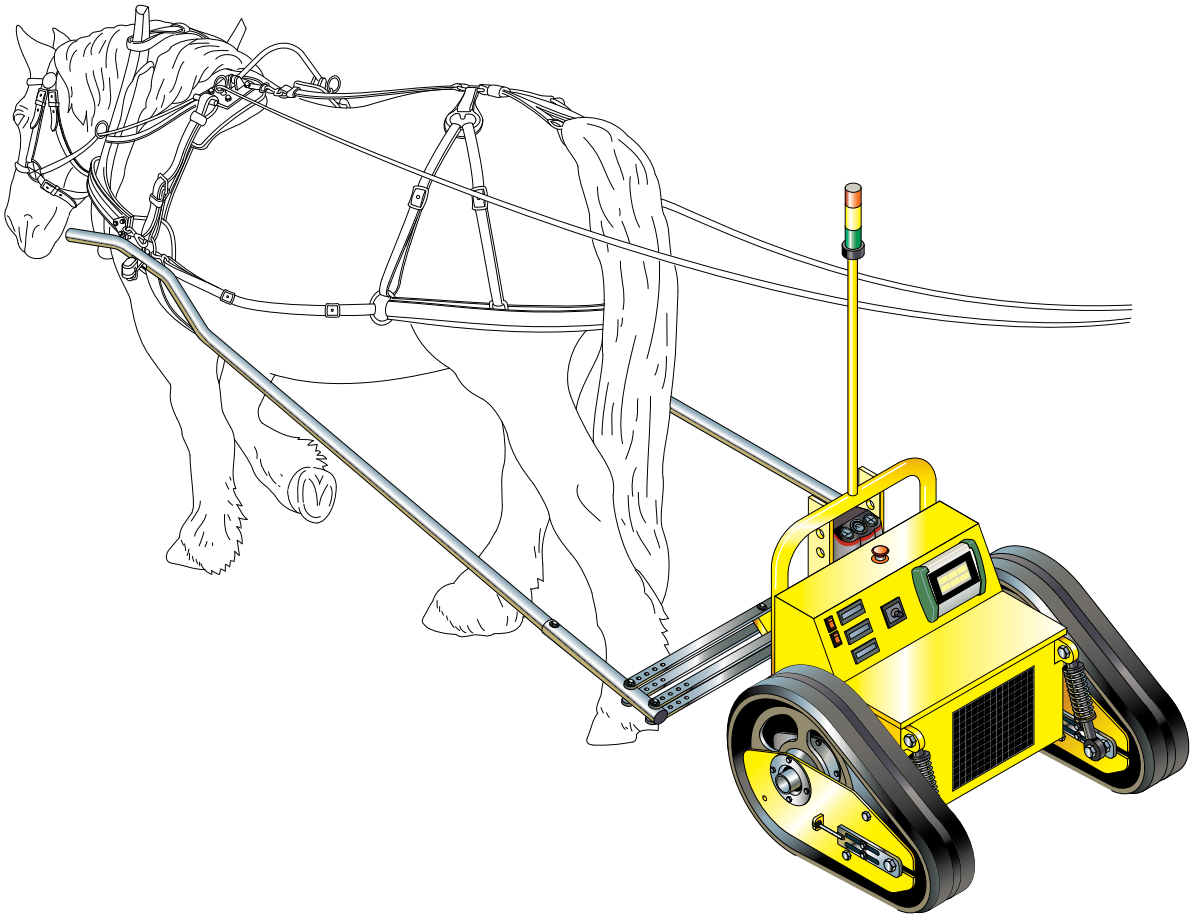
Dyno-test *Concept 1.0*



DYNAMOMETER
for evaluating the draft performances of the
SWEDISH WORKHORSE BREEDS

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Introduction

Dynamometers for measuring the draft force of workhorses were in use to mid of the last century, mainly in USA, but also in different European countries. These test apparatuses generated the load by simply ground dragging weights or in a later development stage by more advanced technologies, e.g. wagons with wheel driven hydraulic pumps acting against adjustable valves [1].

All these systems had the inherent disadvantage that the test conditions could not be reproduced correctly. In the first case, the friction coefficient between the load and the ground is not a fixed value, but is depending on various factors like the surface composition and texture, the later influenced by temperature and moisture. On hydraulic systems, the oil viscosity varies with the heat, created by the system itself due to the pressure increase in the oil, resulting in varying oil flow properties.

It should be noted that many other solutions were invented over time. However, most of the studies date back to the Forties and Fifties and their results must be seen within the context of their own time [2].But also newer studies on the draught capacities of workhorses could not rely on suitable test equipment, which made it difficult to evaluate the results scientifically [3].

Contrary to all these pure mechanical systems of the bygone time, the innovative design of the new Dyno-Test Concept 1.0 dynamometer is based on a contact-less electric hysteresis brake. State-of-the-art in test benches for electric motors or small combustion engines, this technology can also be found in fitness or diagnostic equipment for humans, thanks to its excellent brake torque repeatability.

The braking effect is generated solely by magnetic forces and not by friction or shear forces. By generating absolutely regular and smooth, continuously variable and speed-independent torque loads, without any friction between the components, the hysteresis brake technology suits very well to a workhorse dynamometer. Especially for testing young and inexperienced draft horses, the easy-start characteristic and programmable load increase is a clear step forward.

Picture 1: *Draft force tests in Ultuna - Uppsala 1952 [4]*

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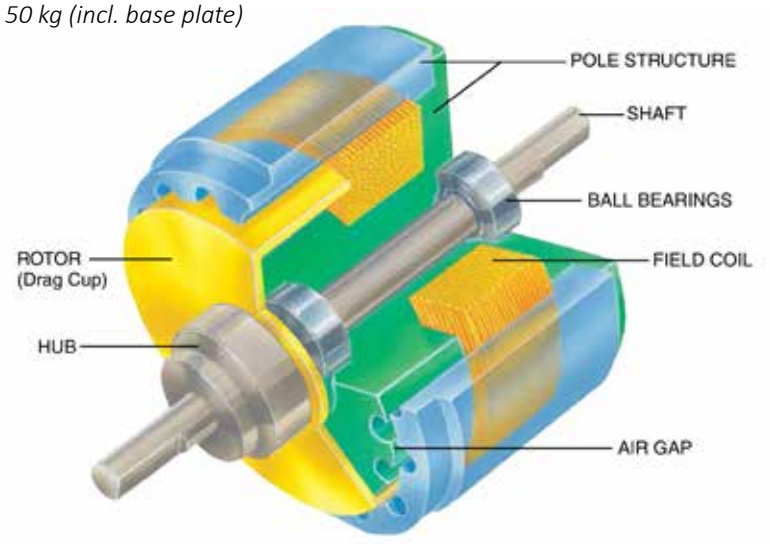
Technical description

By the hysteresis brake in the Dyno-test Concept 1.0 dynamometer, the required draft power is step less adjustable from 0 to 2,4 kW. Three on-board high-performance AGM batteries supply the electric supply tension of 30 DCV for the brake as well as of 12 DCV for the electronic control device. An electronic on-board battery maintainer and charger completes the electric system.

Outside diameter: 226 mm
Total width: 312 mm (incl. coupling shafts)
Weight: 50 kg (incl. base plate)

***Picture 2**: 3D-view of the Magtrol hysteresis brake HB-3500M-2 [5]*



***Picture 3:** Components of a hysteresis brake [7]*

The hysteresis brake is activated via twin rubber tracks with double-sided freewheel hubs assuring, together with an adjustable overall weight and fully spring suspension of both drive units, a non-slip operation. A rotational speed increase of 45% within the drivetrain guarantees the proper operating conditions of the hysteresis brake [6]. The load control of the hysteresis brake is done by varying the direct current < 3 A through the excitation coil. All electrical operating values are below dangerous limit values.

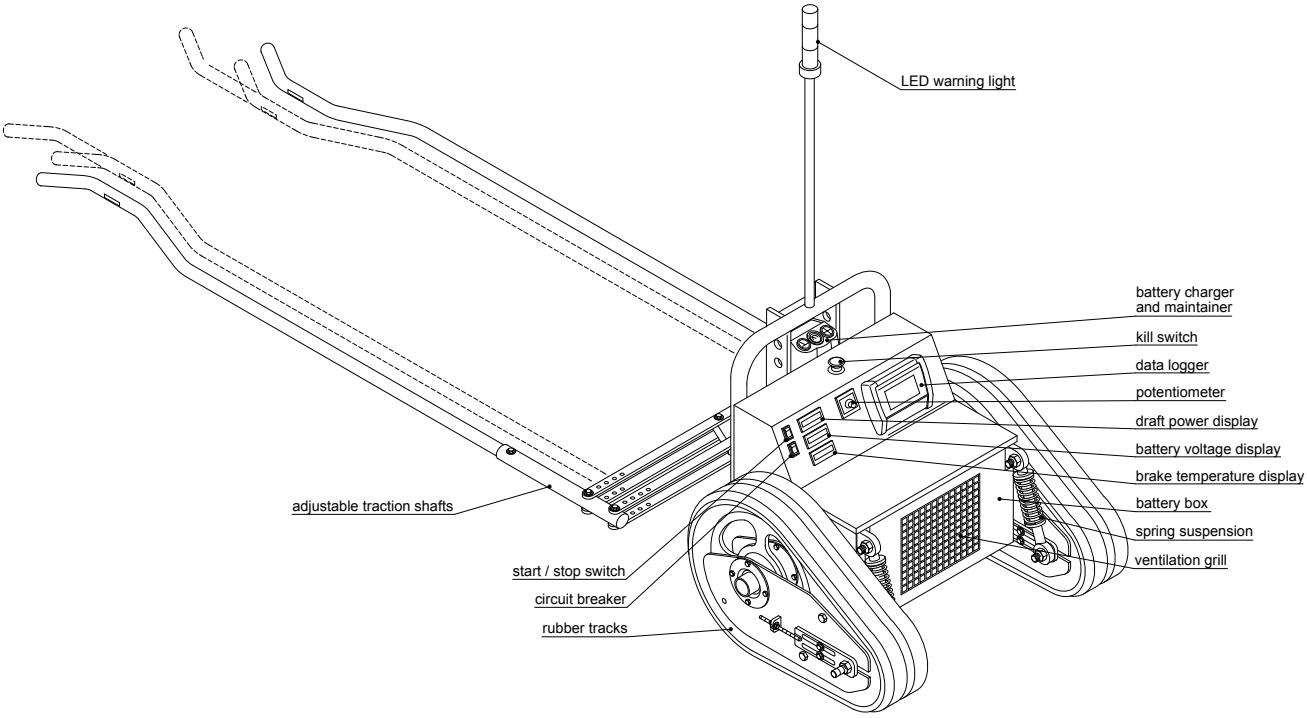
Hysteresis brakes are largely independent of temperature fluctuations and other environmental influences. The kinetic energy, as the horse's applied energy into the braking system, is converted by the electric brake into heat. In order to assure an error-free operation, electric fans with 12 DCV operating tension, dissipate the thermal energy out of the dynamometer. Furthermore, the complete cooling down of the dynamometer is assured by the time needed for unhitching and hitching of the test horses.

The horse's hitch device, entirely made in stainless steel, is spring-suspended and fully adjustable in width and length in order to meet all horse sizes. The height of the hitching point and by that the angle of draft are infinitely variable.

All the sensors, except for the horse's heartrate, are fully integrated in the traction shafts as well as in the drivetrain and brake assembly. They are not only used for measuring purposes, but also for the continuous monitoring of the correct functioning of the dynamometer.

Apart from the electric fans inside the brake casing, there is no other noise generated by the dynamometer. All operating parameters such as the set draft power, the battery tension as well as the operating temperature of the hysteresis brake can be read on digital displays and are stored in the data logger. LED warning lights make it possible to draw attention to functional problems. A kill-switch, in easy reach, enables the test equipment to be safely switched off in an emergency.

During the design process of the Dyno-test Concept 1.0 dynamometer, particular attention was paid that only standard parts from European manufacturers were selected. This makes the complete measuring device repair-friendly ensuring that also long-term studies and test series can be run.



Picture 4: *Main components of the Dyno-test Concept 1.0 dynamometer*

The following values can be measured:

- Draft force (peak and average) to pull a set load
- Time to pull a set load over a set distance
- Time for exerted draft force to fall below a specific level
- Motion equilibrium of the horse (left/right side shoulder movement)
- Force equilibrium of the horse (left/right side draft forces)
- Physical stress of the horse (heart rate)

Additionally, the dynamometer is equipped with two high-speed cameras to record the horse's motion. Other tests, e.g. lactate values, have to be done separately on the horse.

The measuring device consists of the following components:

- Three draft force sensors (to measure the left side / right side / total draft forces)
- Two motion sensors (to measure the left / right side movements of the horse's shoulders)
- One angle sensor (to measure the angle of draft)
- One speed sensor (to measure the motion speed)
- One electric tension sensor (to check the required draft power)
- One electric current sensor (to check the required draft power)
- One torque sensor (to check the required draft power)
- One rotational speed sensor (to check the slipping of dynamometer / required draft power)
- One temperature sensor (to check the electric brake heating)
- One heart rate sensor (to measure the horse's physical stress)
- One data logger incorporated in the dynamometer (to record all measurement values)

The draft force sensor and data logging system has been developed yet in 2010 and has proofed its suitability and a reliable functioning by many field tests. The fine-tuning of the measurement data acquisition has been done by a workshop together with partners from France and Switzerland in 2011 at invitation of the Swiss National Stud Farm in Avenches.

Picture 5: *Double-sided draft force sensors with 5-channel data logger system*

All sensors work plug & play via a patented plug system, wherein each sensor connector includes an EE-PROM ensuring that the sensor is automatically identified, scaled and calibrated. Furthermore, the data logger is correctly configured in the same time. By working on 12 DCV supply voltage, the 10-channel data logger permits an autarkic measurement data acquisition. The operation is both intuitive and easy to use via icons on a brightly lit, colourful 5.7" touch screen [8]. All the measured data is stored in an external memory stick with micro SD card. This facilitates the data transfer to any commercially available PC later on. The detailed data analyzing and the graphical representation can be done with any usual data processing program, except the overlay of the video sequences, which needs a special software [9].

Picture 6: *Ahlborn Almemo 710 V7 data logger [8]*

The following pictures show some examples of horse drawn equipment tests, using draft force sensors and data logging systems in various configurations, recently done in Sweden.

Picture 7: *Draft force tests on Swedish horse drawn equipment*

The programming of the brake's electronic control and measurement display is based on an open-source hardware and software. This makes adaptations easy at a later time. The different test procedures and all parameters can be programmed in advanced and simply called-up by the electronic control prior to the trials. A redundant measuring method, based on electrical (tension and current) as well as mechanical (torque and rotational speed) real-time measurements, allows controlling constantly the draft power and the correct functioning of the dynamometer. Because the hysteresis brakes relies purely on a magnetic action, working through an air gap, to develop torque, there are no

Picture 8: *Evaluating the balance of forces in a multiple hitch.*

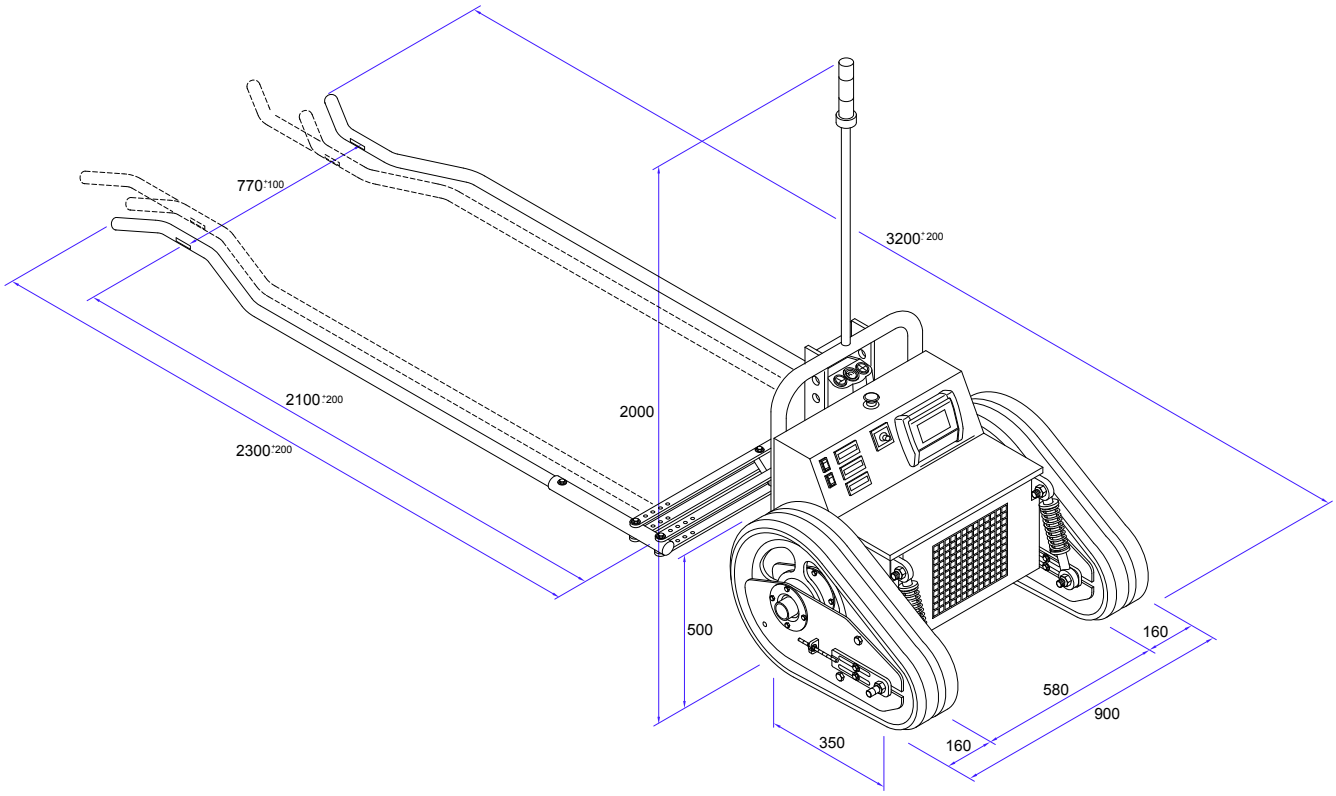
active components in contact and virtually no wear, except for the ball bearings in the brake and the drivetrain, which ensures a long technical lifetime of the dynamometer.

The tests can be done with standardized harness or with the horse's own harness. The standardized harness are of the Swedish Värmland style and in 25, 32 and 35 tum size for Gotland Russ, North Swedish respectively Swedish Ardennes horses.

In order to facilitate the transport, the outer dimensions of the dynamometer were selected so that the whole device, after dismounting of the traction shaft assembly, fits on a small car trailer or on the loadbed of any mid-size pick-up.

A fully illustrated manual in English explains the test procedures as well as the correct operation and maintenance of the dynamometer Dyno-test Concept 1.0.

Picture 9: *Agrizeta Z24 modified rubber track drive*



Picture 10: *Main dimensions of the Dyno-test Concept 1.0 dynamometer*

References

[1] Testing draft horses
E.V. Collins and A. B. Caine
Agricultural Experiment Station,
Iowa State College of Agriculture
and Mechanic Arts
1926

[2] Studies on the draught forces
of animals - Development of a method
using strain gauges for measuring forces
between hoof and ground
Gustaf Björck
Almqvist & Wiksells, Upsalla
Acta Agriculturae Scandinavica – Supple
ment. 4
1958

[3] Towards objective draught
performance measurement in heavy horses
Zhao Ying Cui
Katholieke Universiteit Leuven,
Faculteit Bio-ingenieurswetenschappen
2012

[4] Uppsala - Bild Upplandsmuseet

[5] Freins et embrayages à hystérésis
1ière édition française Rev A
Magtrol S.A., Rossens
2019

[6] Catalogo 2020, prima edizione
Agrizeta di Bagnesi Silvia, Montichiari
2020

[7] Freins à hystérésis HB – Fiche technique
Magtrol S.A., Rossens
2019

[8] Almemo Gesamtkatalog
Ahlborn GmbH, Holzkirchen
2019

[9] Almemo Handbuch
Ahlborn GmbH, Holzkirchen
2019