

Acceleration Pattern

Results of pass-by noise measurements carried out within the frame of a running UBA project

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Speed measurements were carried out with a radar device.

Between –20 m to +30 m (relative to microphone sphere) the sound level on both sides of the vehicle, the vehicle speed and the engine speed were measured instantaneously and the data were recorded with a sampling rate of 0,5 m.

The following figures show the acceleration pattern derived from the speed signal results

- **Vehicles with manual transmission:**

- Even for vehicles with manual gearboxes there is a first acceleration phase where the acceleration increases steeply from 0. This phase lasts at least 5 m.
- The following phase can be either nearly constant or further increasing with lower slope or even decreasing, depending on the individual vehicle design. This different behaviour could even occur for the same vehicle in different gears/driving conditions.

- **Vehicles with automatic transmission:**

- A downshift normally occurs in selector position “drive” at speeds around 50 km/h. The downshift could cover 1 gear but a 2 gears downshift was also quite frequently found. In one case even a 3 gears downshift occurred.
- Delay phases, where the acceleration remained close to 0, were often found associated with those downshifts. Typical delays for downshifts were 10 m for downshifts by 1 gear and up to 15 m for downshifts by 2 gears, followed by the initial increase phase of 5 to 7 m. That means that the “true” acceleration is only reached over the last 5 m (in case of downshifts by 1 gear) or even only at BB (in case of downshifts by 2 gears).
- Measurements carried out at much lower starting speeds (around 20 km/h) or at a selector position next to “drive” and the example of vehicle 10 showed that the delay can be significantly reduced.

- **Vehicles with automatic transmission (continued):**

- For 3 of 7 vehicles the target acceleration of the D/ISO method (related to AA'_BB') was reached in gear selector position "drive". For 1 case the target acceleration was not reached and for the remaining 3 cases the target acceleration was reached for 50% of the measurements.

- **Acceleration calculation:**

- Since the acceleration determines the gear ratios for the measurements and since the acceleration showed no uniform behaviour, high precision speed measurement devices must be used.
- The best way to characterise the acceleration behaviour is the instantaneous speed measurement over the whole track length.
- If this is not possible, the speed should at least be measured at AA, PP and BB and the accelerations a_{AA_PP} , a_{PP_BB} and a_{AA_PP} should be calculated.

- **D/ISO method problems:**

- For one vehicle the target acceleration in 3. gear (related to AA_BB) was only reached in 3 of 6 cases. The measurement result was based on these 3 cases. If one would include also the other results, this vehicle does not fit into the systematics of this method, because measurements in 2. Gear would lead to too high engine speeds at BB'.

- **Vehicles with manual transmission:**
 - Use preacceleration to compensate or reduce the initial acceleration increase phase
- **Vehicles with automatic transmission:**
 - Use preacceleration or the selector position next to “drive” to avoid or reduce the delay phases.
 - Do not allow the use of a_PP_BB instead of a_AA_BB
- **All vehicles:**
 - The acceleration should be calculated between AA and BB, shorter distances lead to time spans below 1 s, which is not in line with practical use and does only represent transitional operation.
 - Measure the speed at AA, PP and BB with a high precision and calculate the accelerations a_{AA_PP} , a_{PP_BB} and a_{AA_PP} . Too big differences between a_{AA_PP} and a_{PP_BB} should not be allowed.

The following figures show the acceleration pattern derived from the speed signal results for a series of driving conditions for vehicles with **manual transmission**.

✓ Measurements from $v_{AA} = 20/25$ km/h:

- The acceleration increases over the first 5 m from 0 to $1,5 \text{ m/s}^2$ (2. gear) or 1 m/s^2 (3. gear). After that the acceleration increases still but with a lower slope.

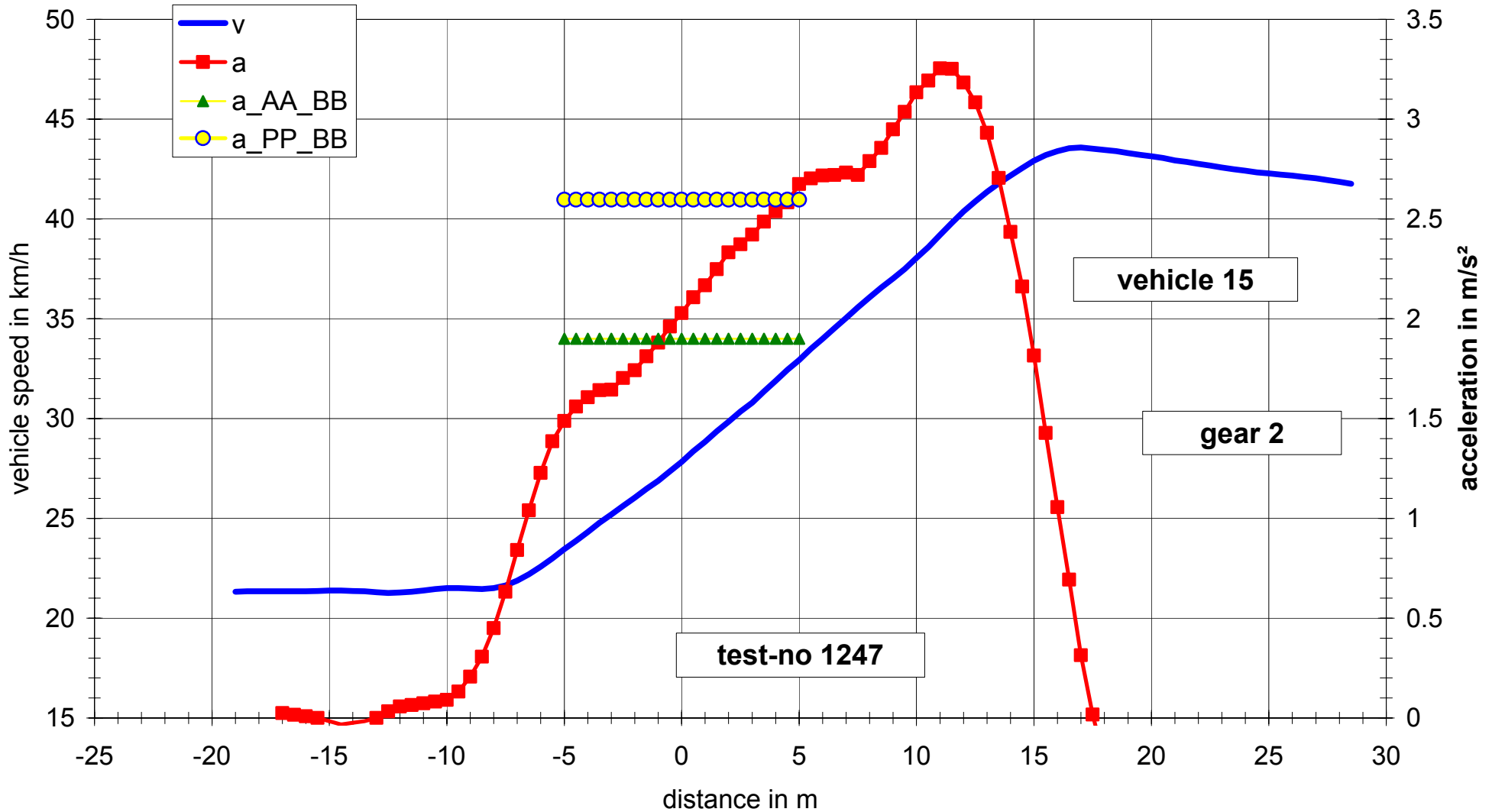
✓ Measurements from $v_{AA} = 50$ km/h (2. Gear) or $n_{AA} = 0,75$ s (3. Gear):

- in 2. Gear the acceleration increases nearly linear over the first 15 m from 0 to $2,2 \text{ m/s}^2$. After that the acceleration increases still but with a very low slope.
- in 3. Gear the acceleration increases nearly linear over the first 15 m from 0 to $1,7 \text{ m/s}^2$. After that the acceleration increases still but with a very low slope.

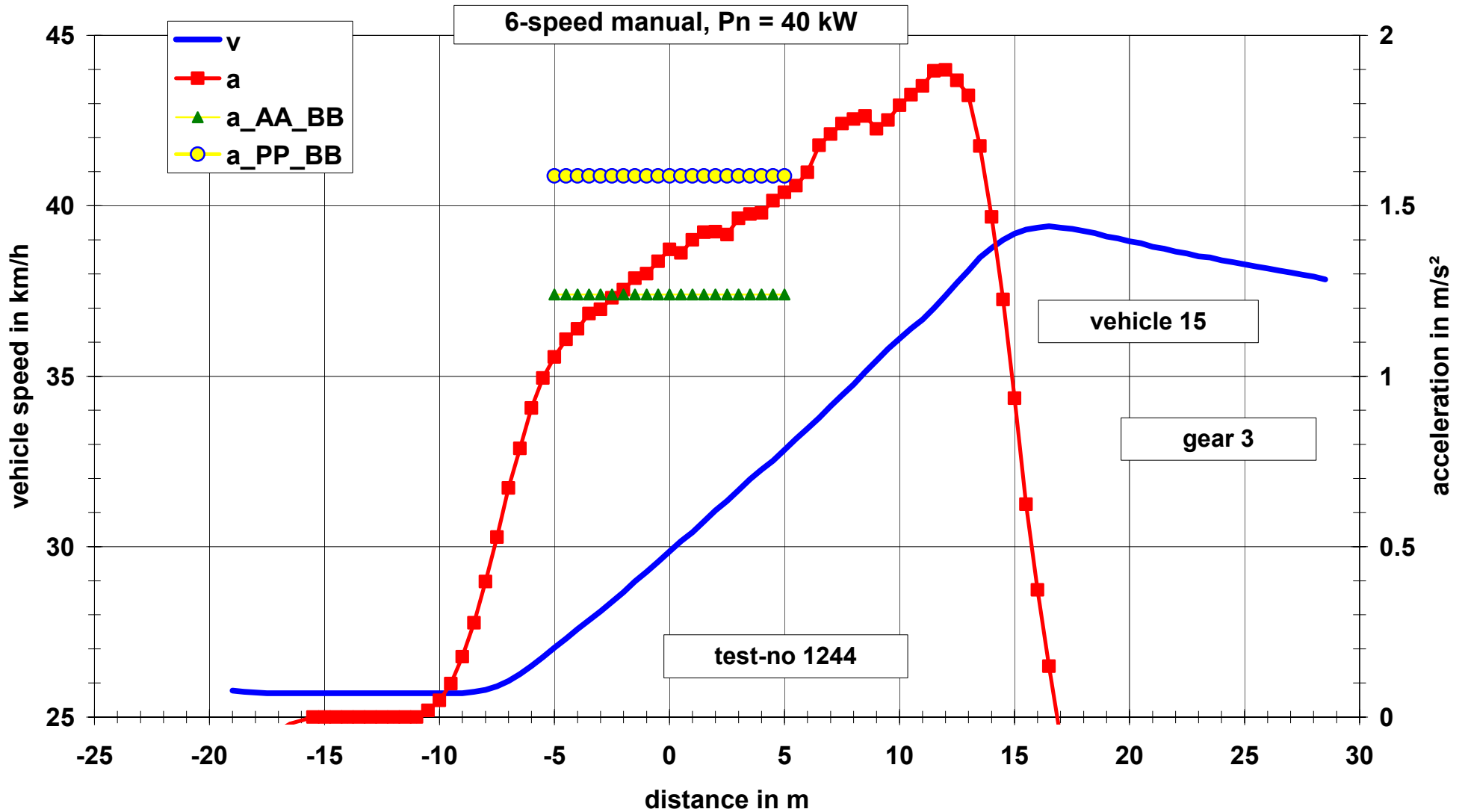
✓ Measurements for the D/ISO method:

- In 3. Gear the target acceleration (related to AA_BB) was only reached in 3 of 6 cases. The measurement result was based on these 3 cases. If one would include also the other results, this vehicle does not fit into the systematics of this method, because measurements in 2. Gear would lead to too high engine speeds at BB. The acceleration pattern are similar to those of the current method.

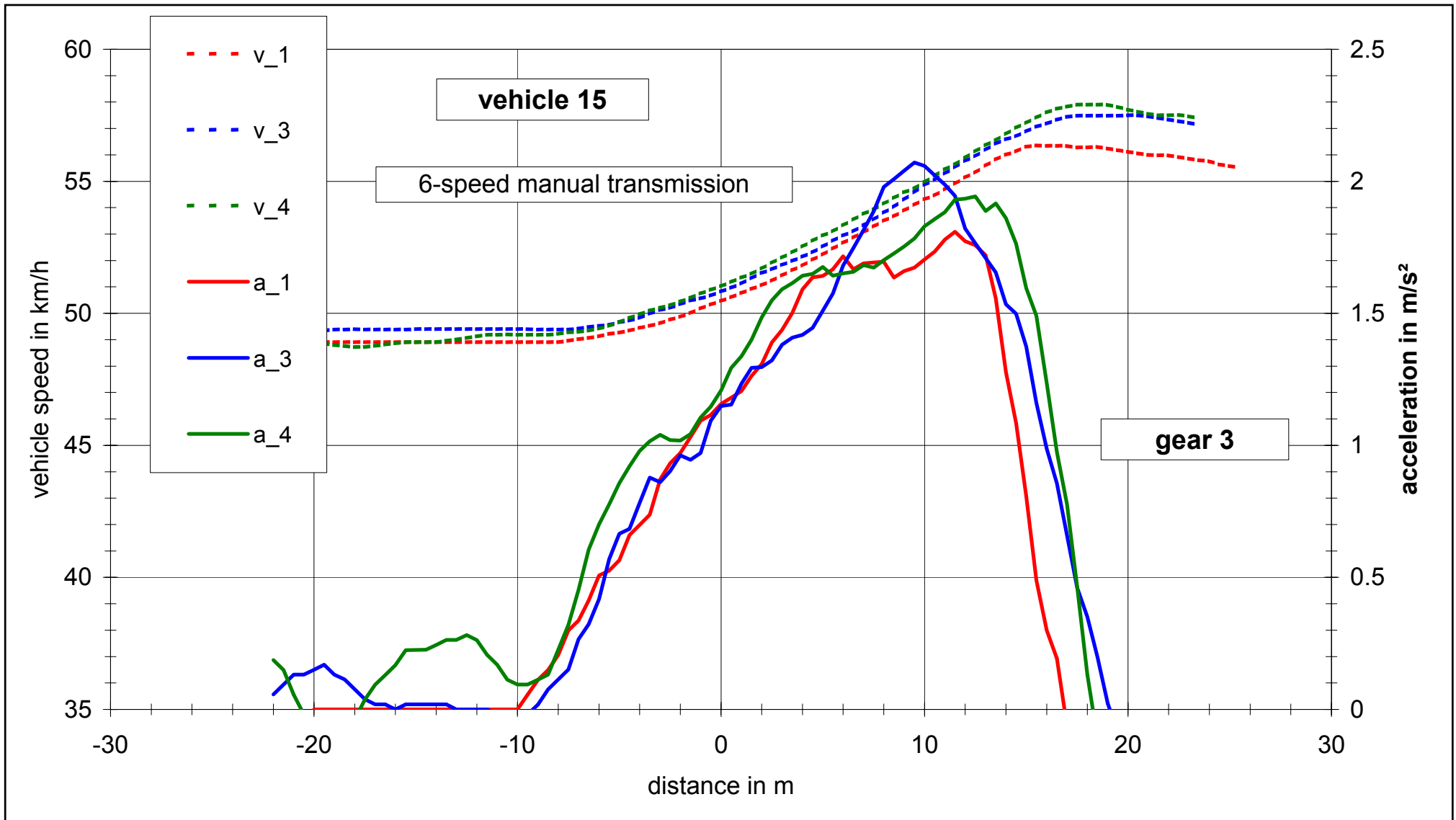
Acceleration Pattern, veh 15, Pn = 40 kW



Acceleration Pattern, veh 15, Pn = 40 kW



Acceleration Pattern, veh 15, Pn = 40 kW



✓ Measurements from $v_{AA} = 25$ km/h:

- The acceleration increases over the first 5 m and keeps then constant with some fluctuations (both for 2. And 3. Gear).

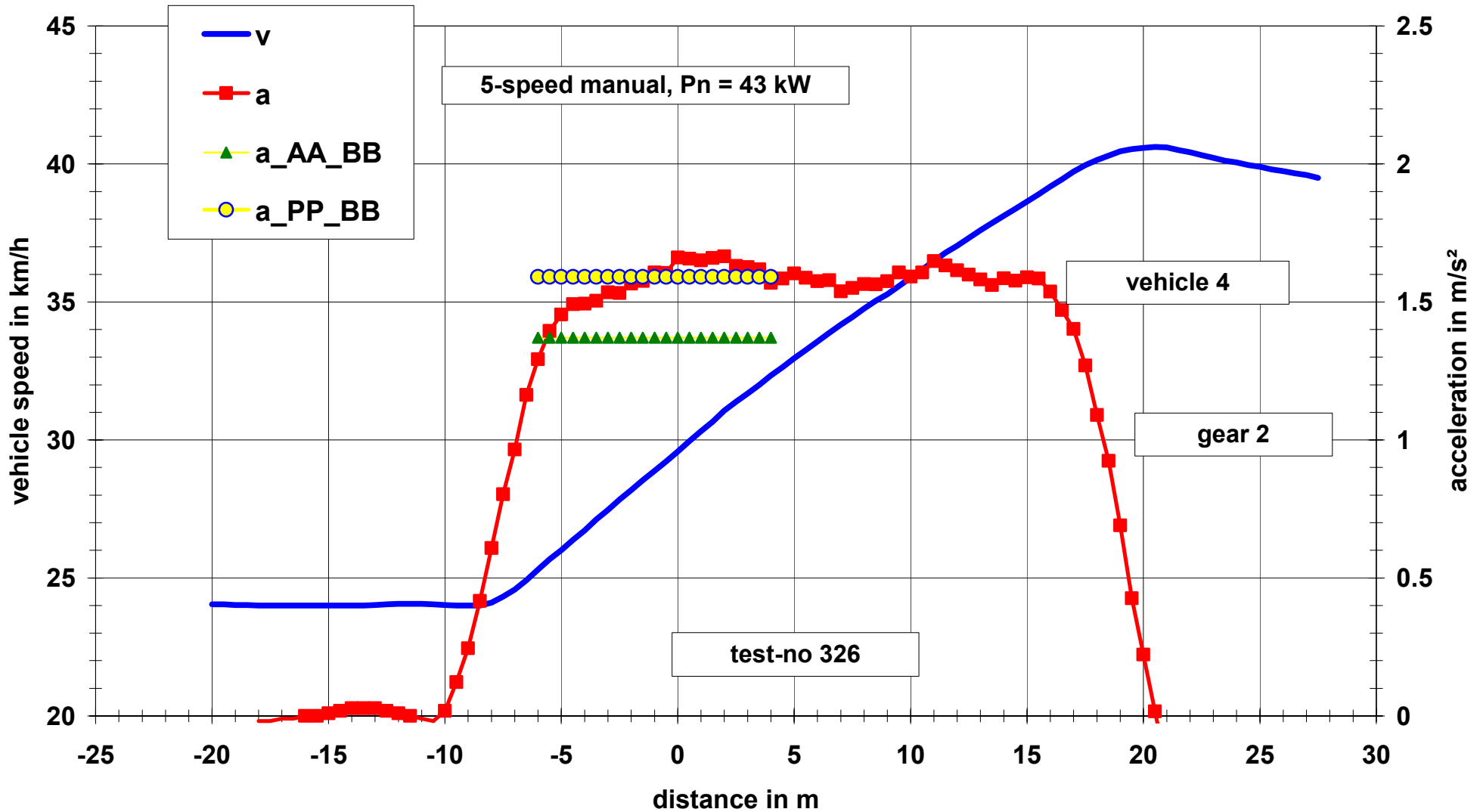
✓ Measurements from $v_{AA} = 50$ km/h (2. Gear) or $n_{AA} = 0,75$ s (3. Gear):

- The results are similar to the measurements from $v_{AA} = 25$ km/h, even for the final acceleration values.

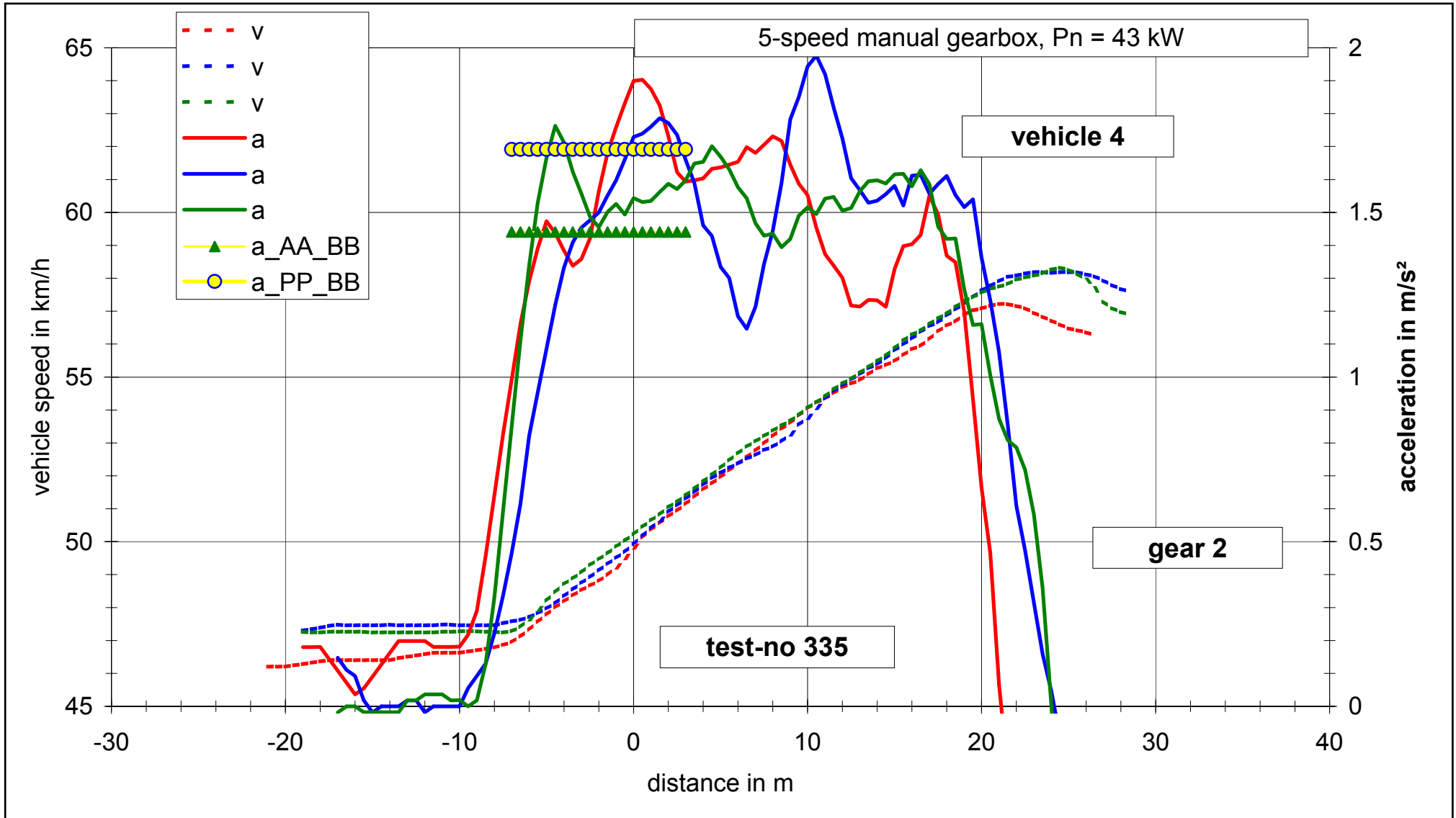
✓ Measurements for the D/ISO method:

- Same as before but high fluctuations of up to $\pm 0,3$ m/s² in the “constant” acceleration phase.

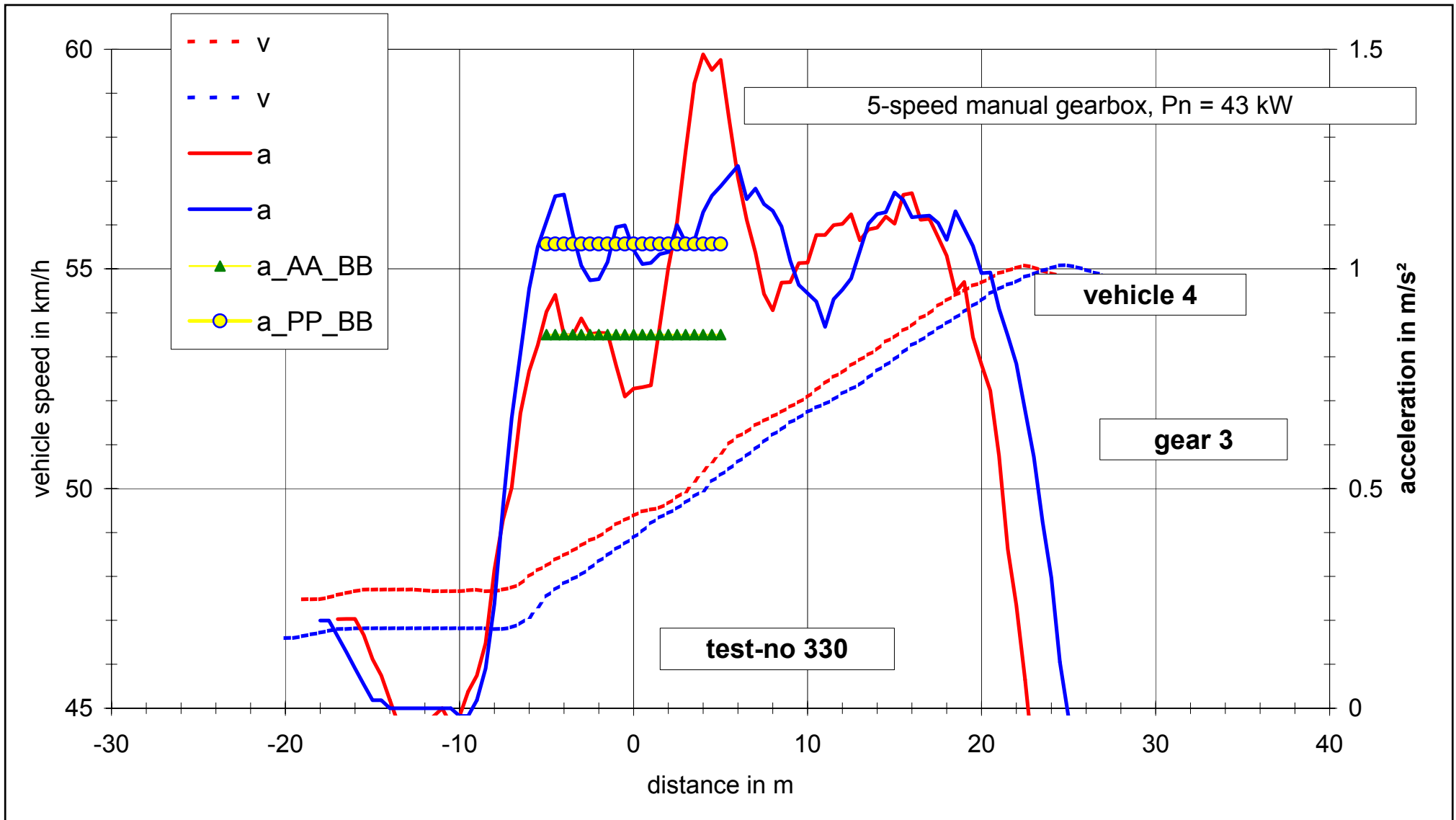
Acceleration Pattern, veh 4, Pn = 43 kW



Acceleration Pattern, veh 4, Pn = 43 kW



Acceleration Pattern, veh 4, Pn = 43 kW



✓ Measurements from $v_{AA} = 20/25$ km/h:

- The acceleration increases over the first 10 m from 0 to 2 m/s². After that the acceleration increases still but with a very low slope.

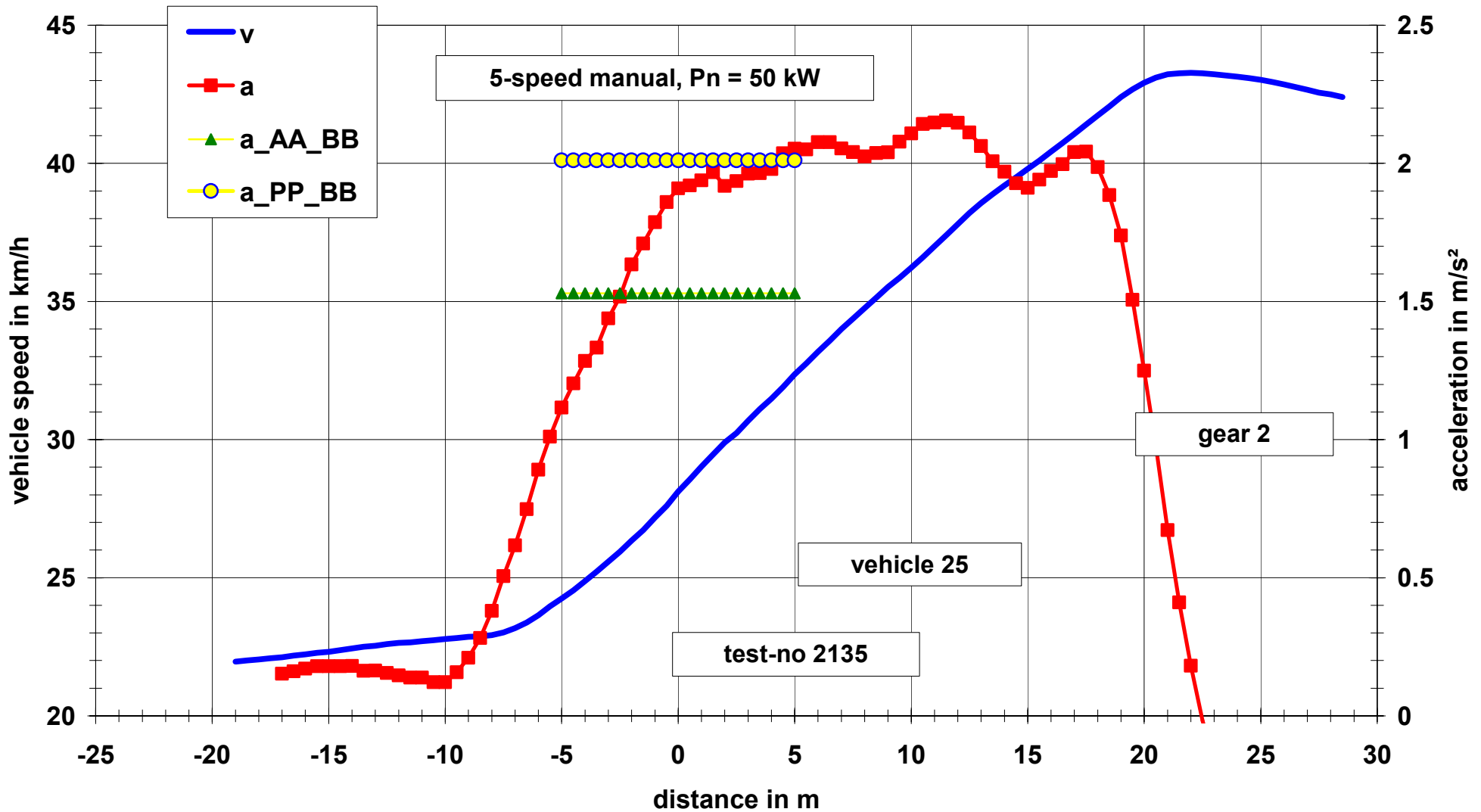
✓ Measurements from $v_{AA} = 50$ km/h (2. Gear) or $n_{AA} = 0,75$ s (3. Gear):

- in 2. Gear the acceleration increases nearly linear over the first 7 m from 0 to 2 m/s². After that the acceleration increases still but with a very low slope.
- in 3. Gear the acceleration increases nearly linear over the first 7 m from 0 to 1,3 m/s². After that the acceleration increases still but with a very low slope.

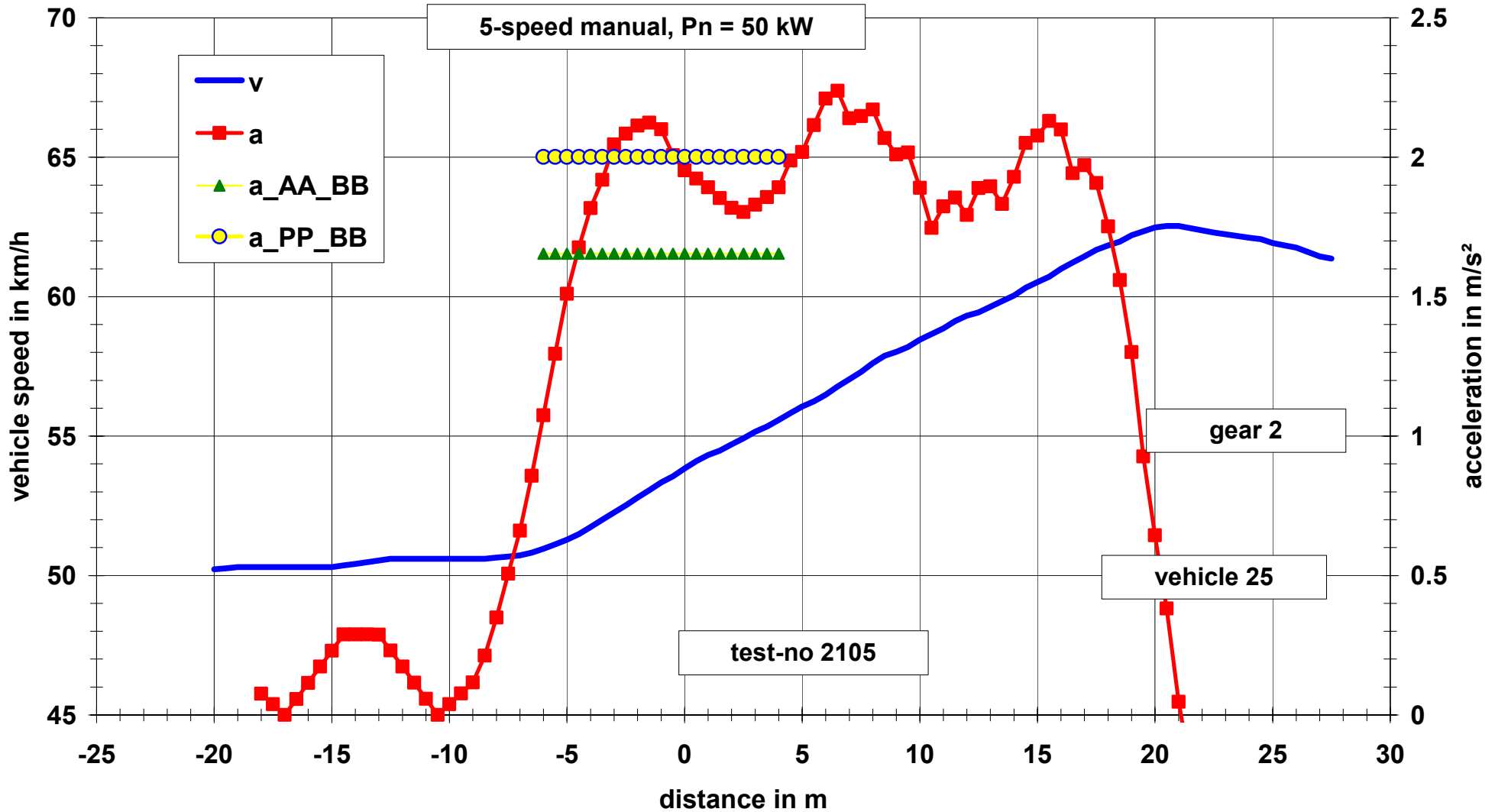
✓ Measurements for the D/ISO method:

- The target acceleration (related to AA_BB) was reached in 3. Gear. The acceleration pattern are similar to those of the current method.

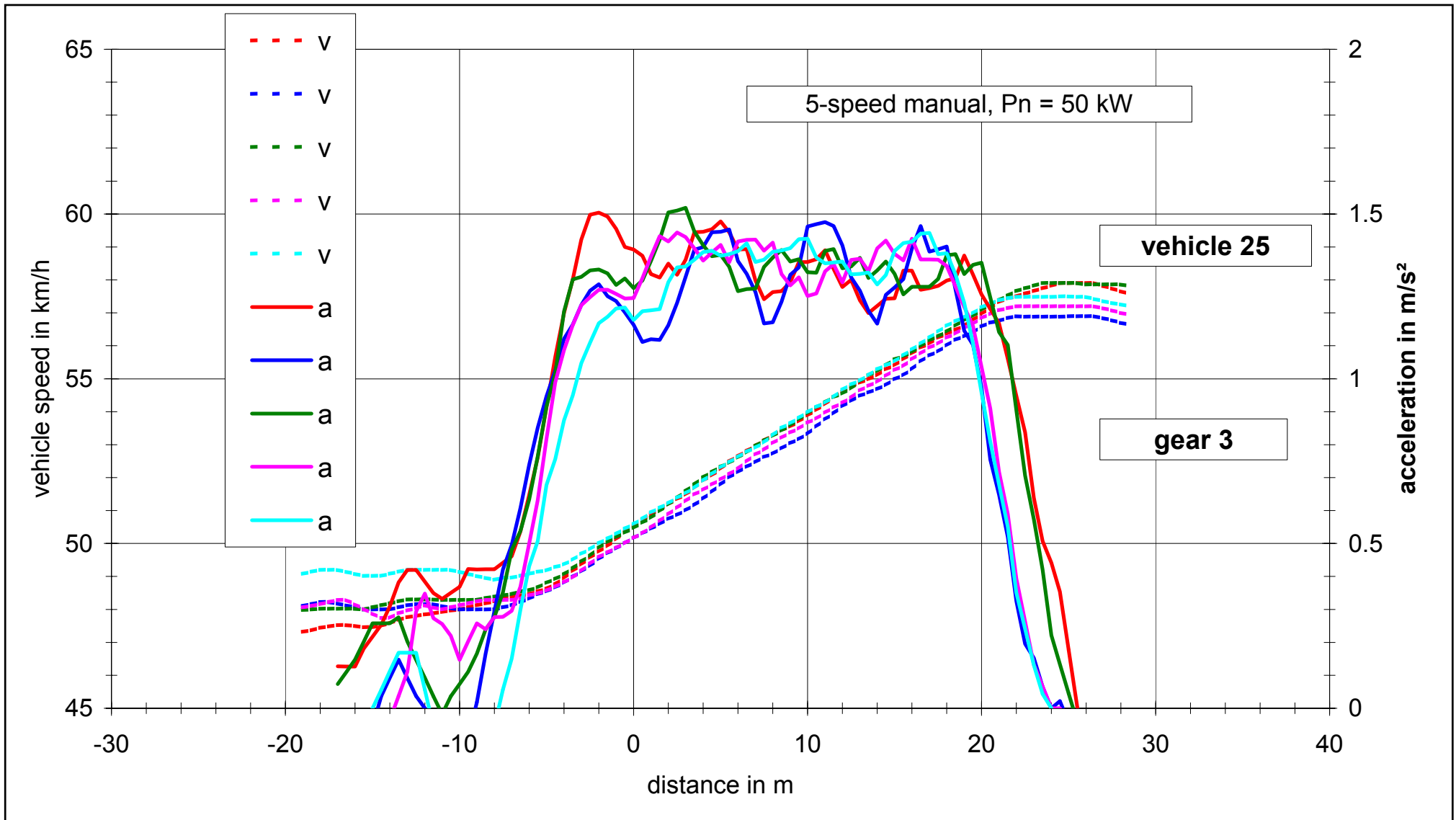
Acceleration Pattern, veh 25, Pn = 50 kW



Acceleration Pattern, veh 25, Pn = 50 kW



Acceleration Pattern, veh 25, Pn = 50 kW



✓ Measurements from $v_{AA} = 20/25$ km/h:

- Typical for this vehicle is a steep increase of the acceleration for the first 5 or 6 m from 0 to $1,5 \text{ m/s}^2$ (2. Gear) or 1 m/s^2 (3. Gear). After that the acceleration still increases but with a lower slope.

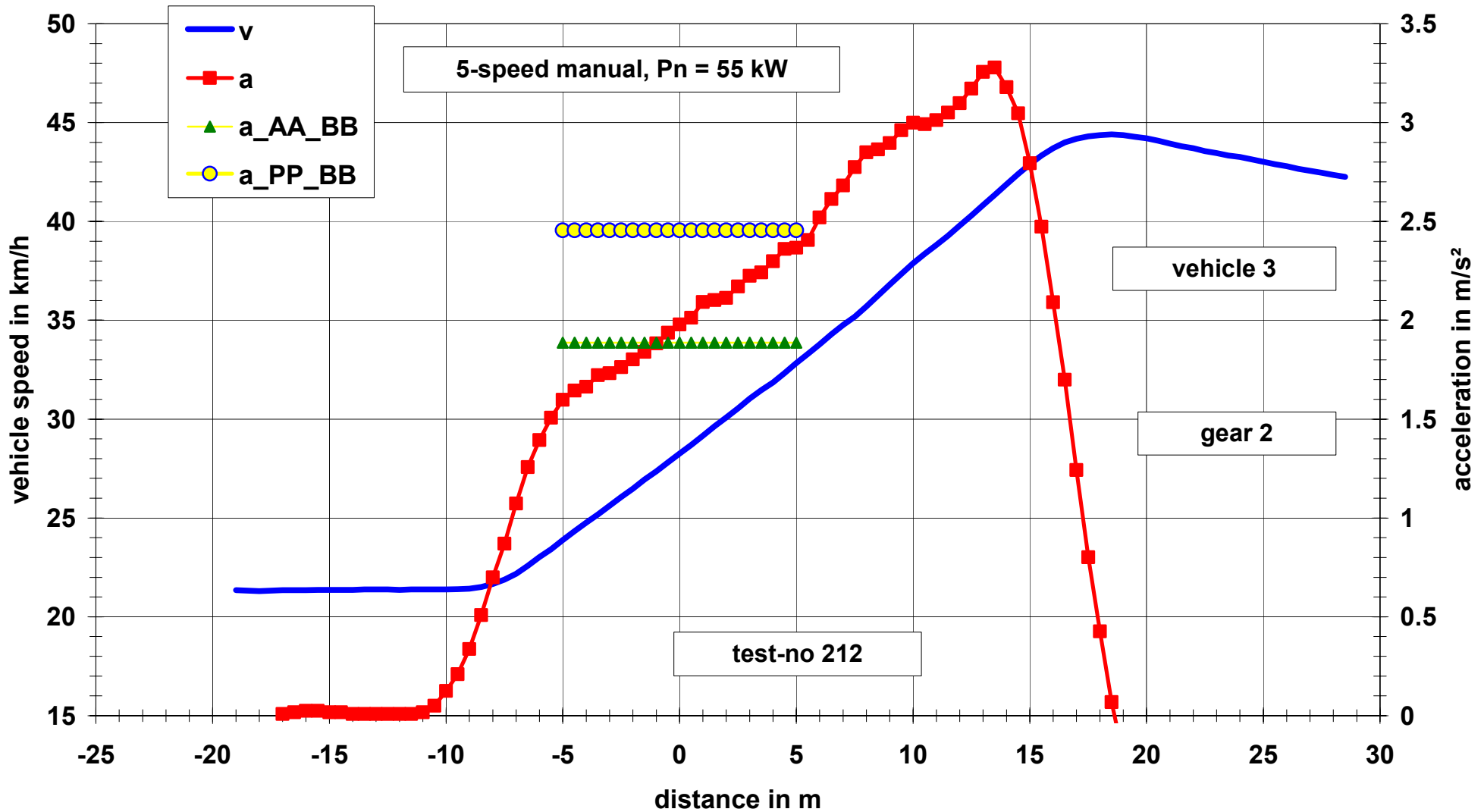
✓ Measurements from $v_{AA} = 50$ km/h (2. Gear) or $n_{AA} = 0,75$ s (3. Gear):

- in 2. Gear the acceleration increases nearly linear over the first 7 m from 0 to $2,5 \text{ m/s}^2$. After that the acceleration fluctuates around a constant value.
- in 3. Gear the behaviour is similar to the 20/25 km/h situation.

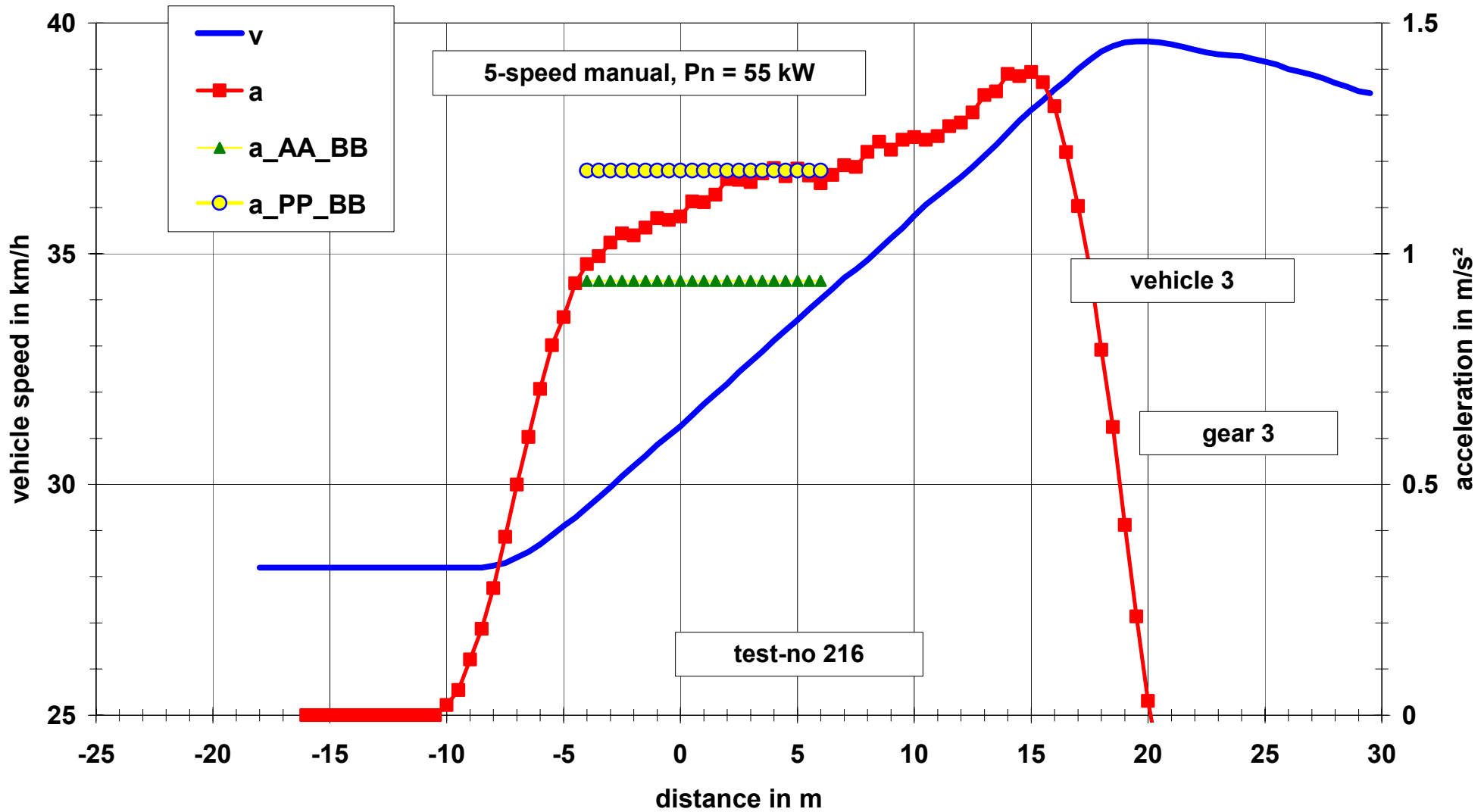
✓ Measurements for the D/ISO method:

- In 3. Gear the target acceleration (related to AA_BB) was exceeded and in 4. Gear not reached. The measurement result was based on both gears. The acceleration pattern are similar to those of the current method.

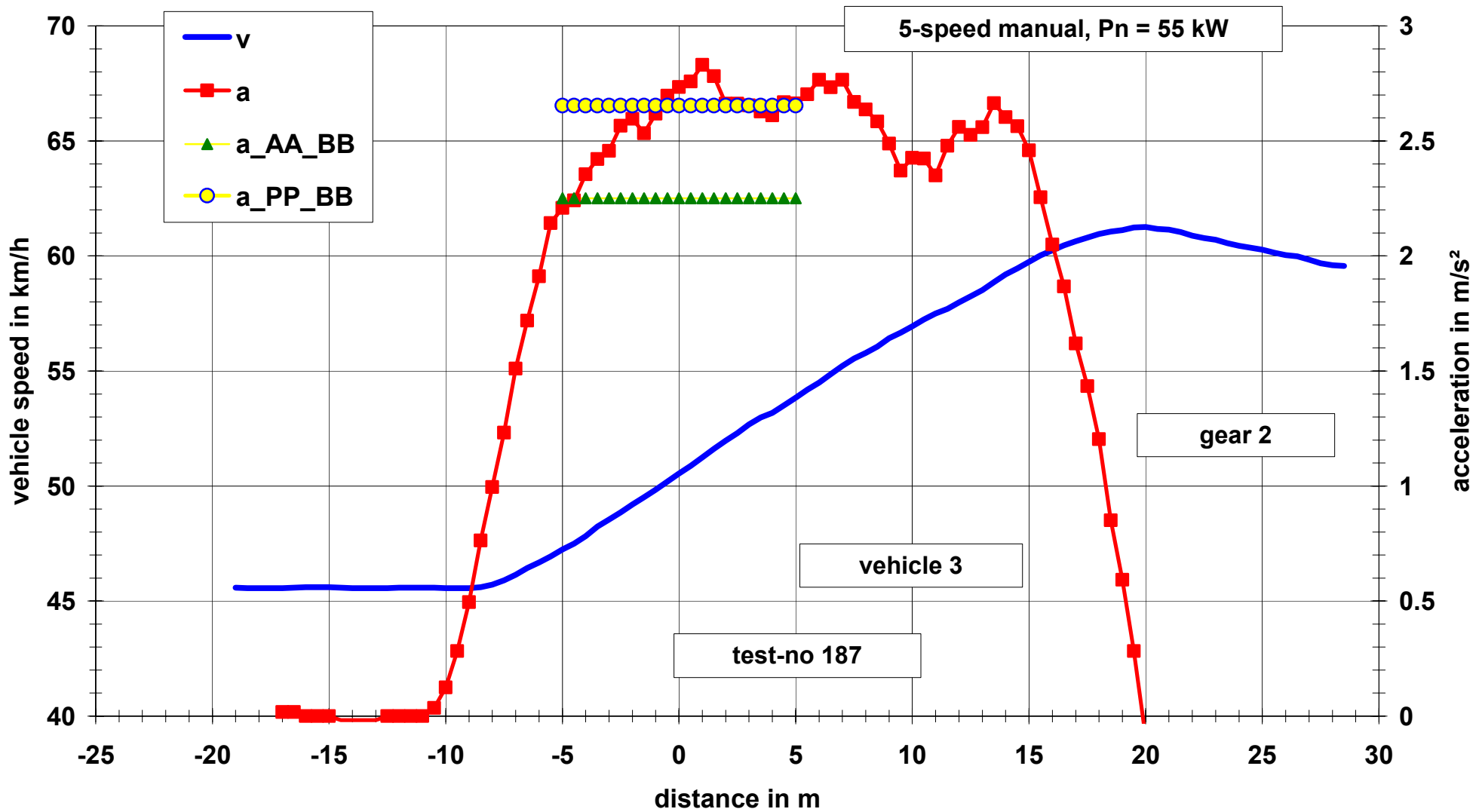
Acceleration Pattern, veh 3, Pn = 55 kW, Diesel



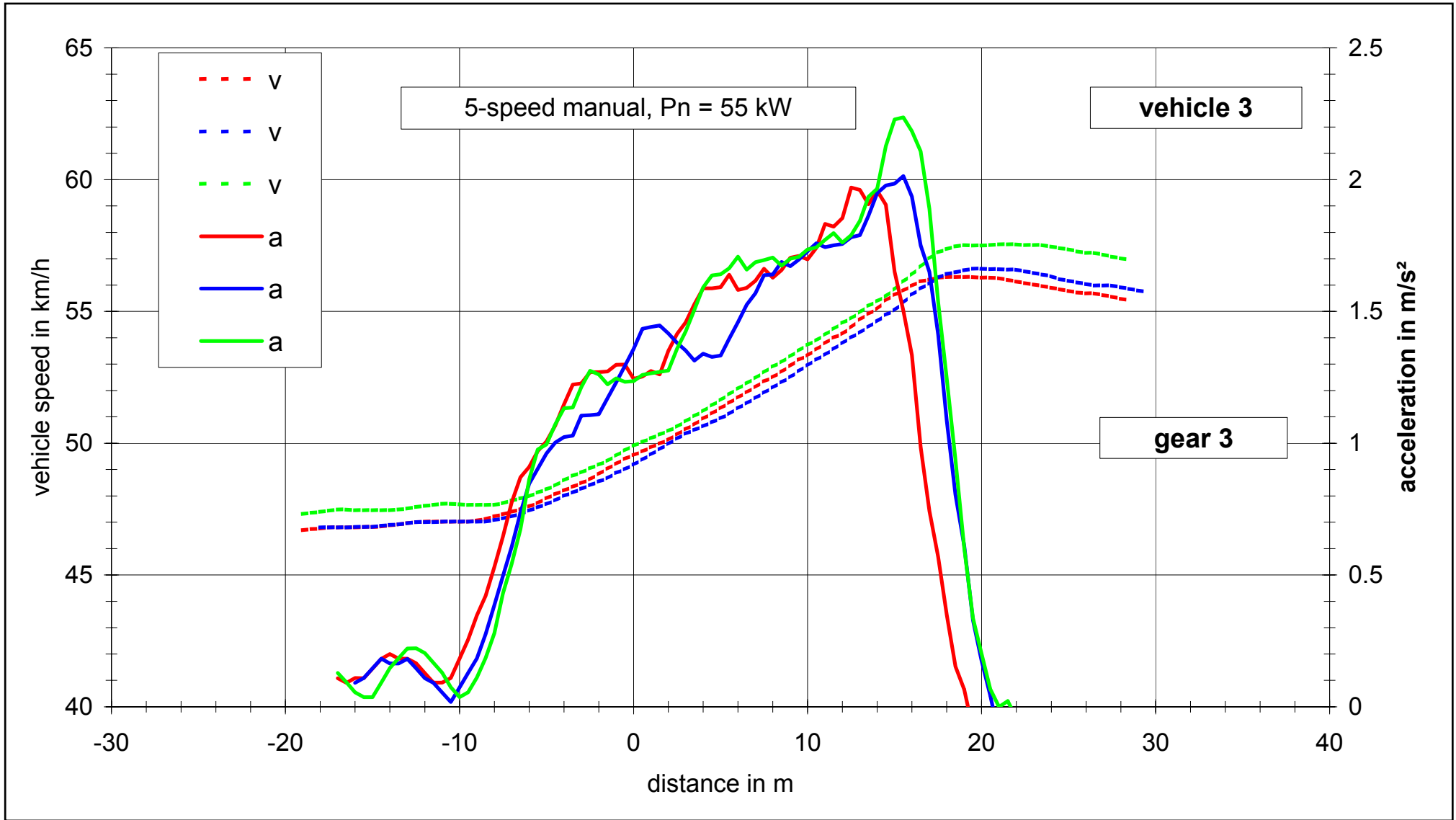
Acceleration Pattern, veh 3, Pn = 55 kW, Diesel



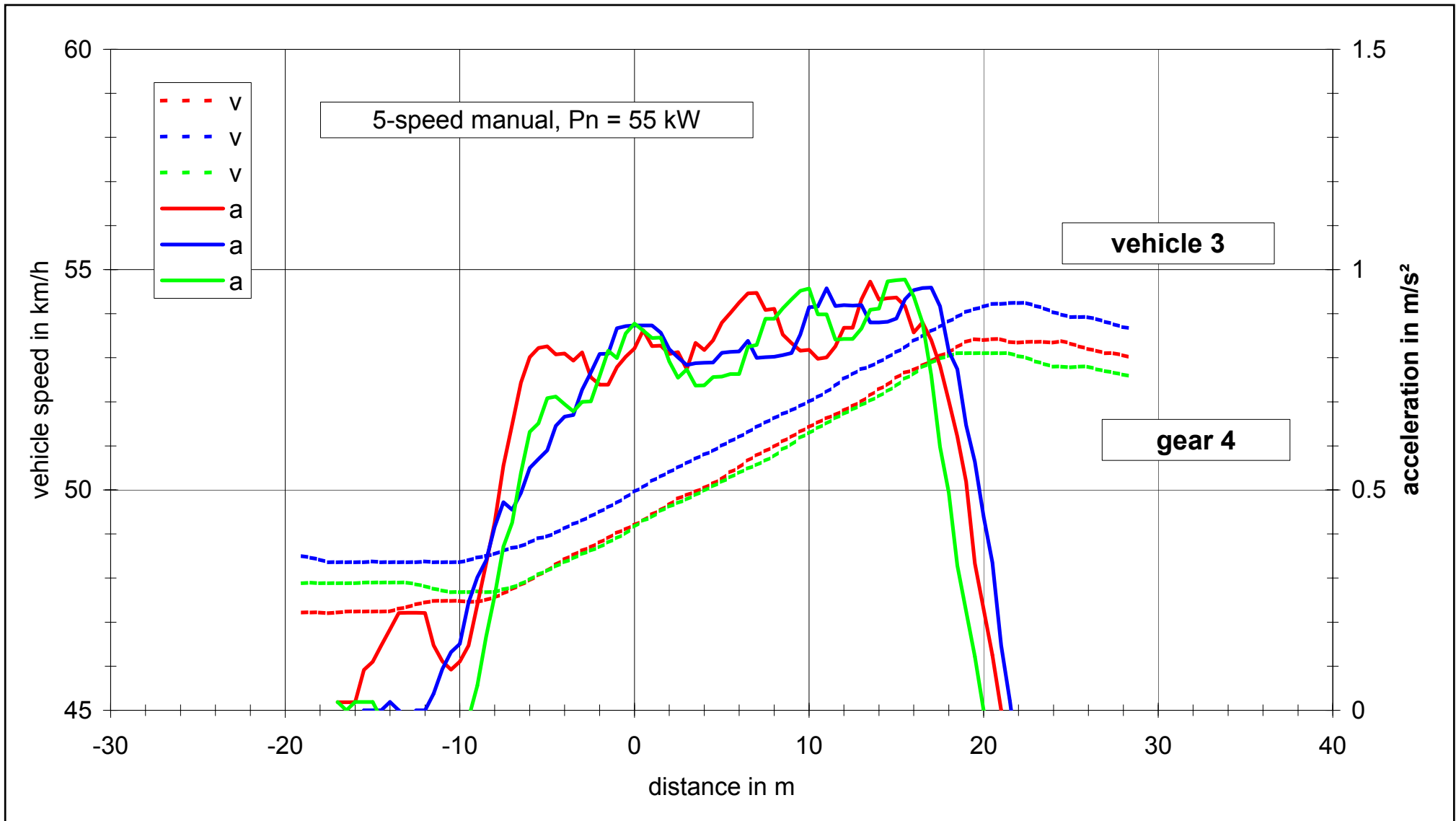
Acceleration Pattern, veh 3, Pn = 55 kW, Diesel



Acceleration Pattern, veh 3, Pn = 55 kW, Diesel



Acceleration Pattern, veh 3, Pn = 55 kW , Diesel

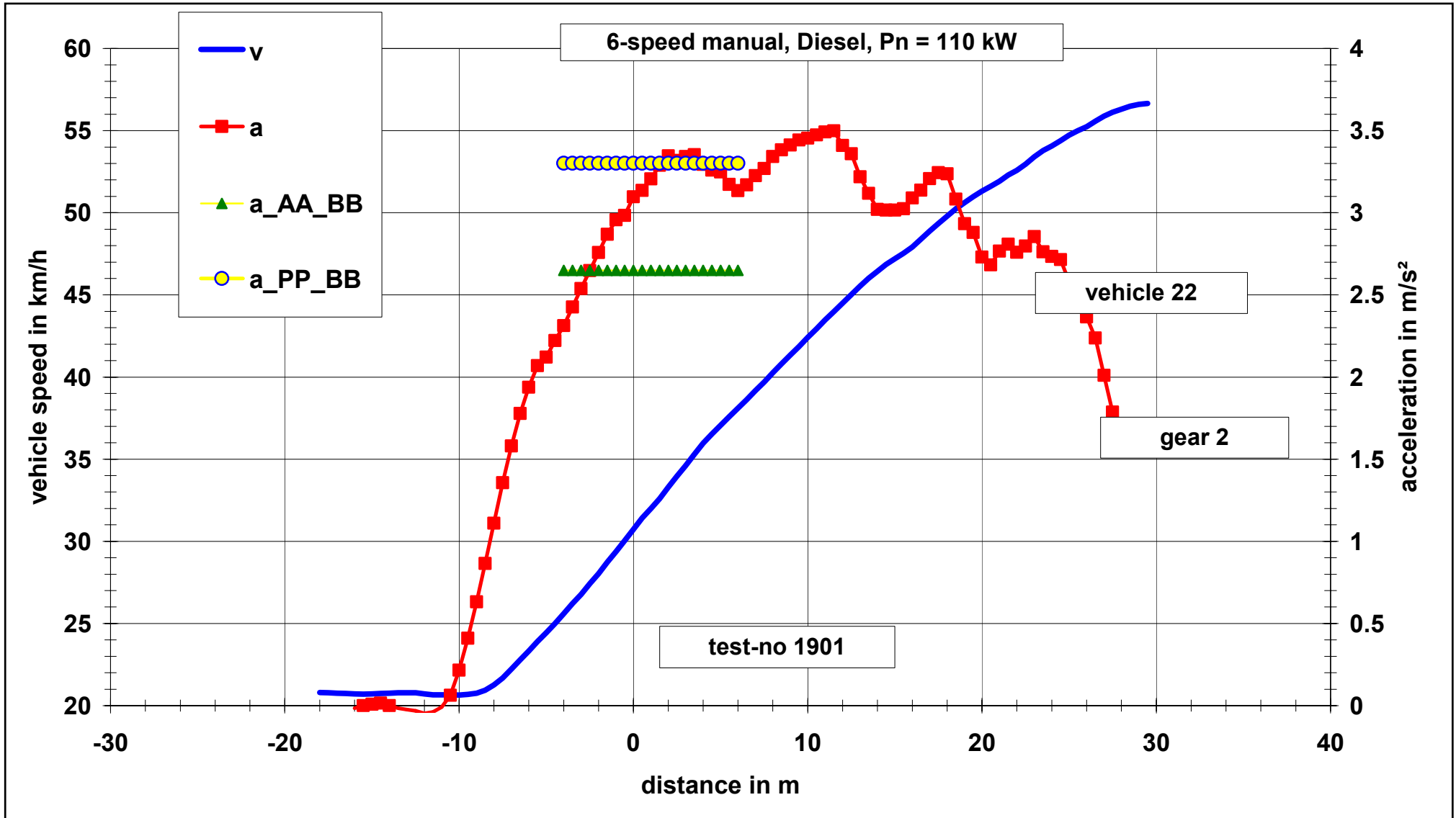


Measurements in 2. Gear showed an increase of the acceleration from 0 to a maximum within the first 12 m distance. After that the acceleration decreased slightly with fluctuations.

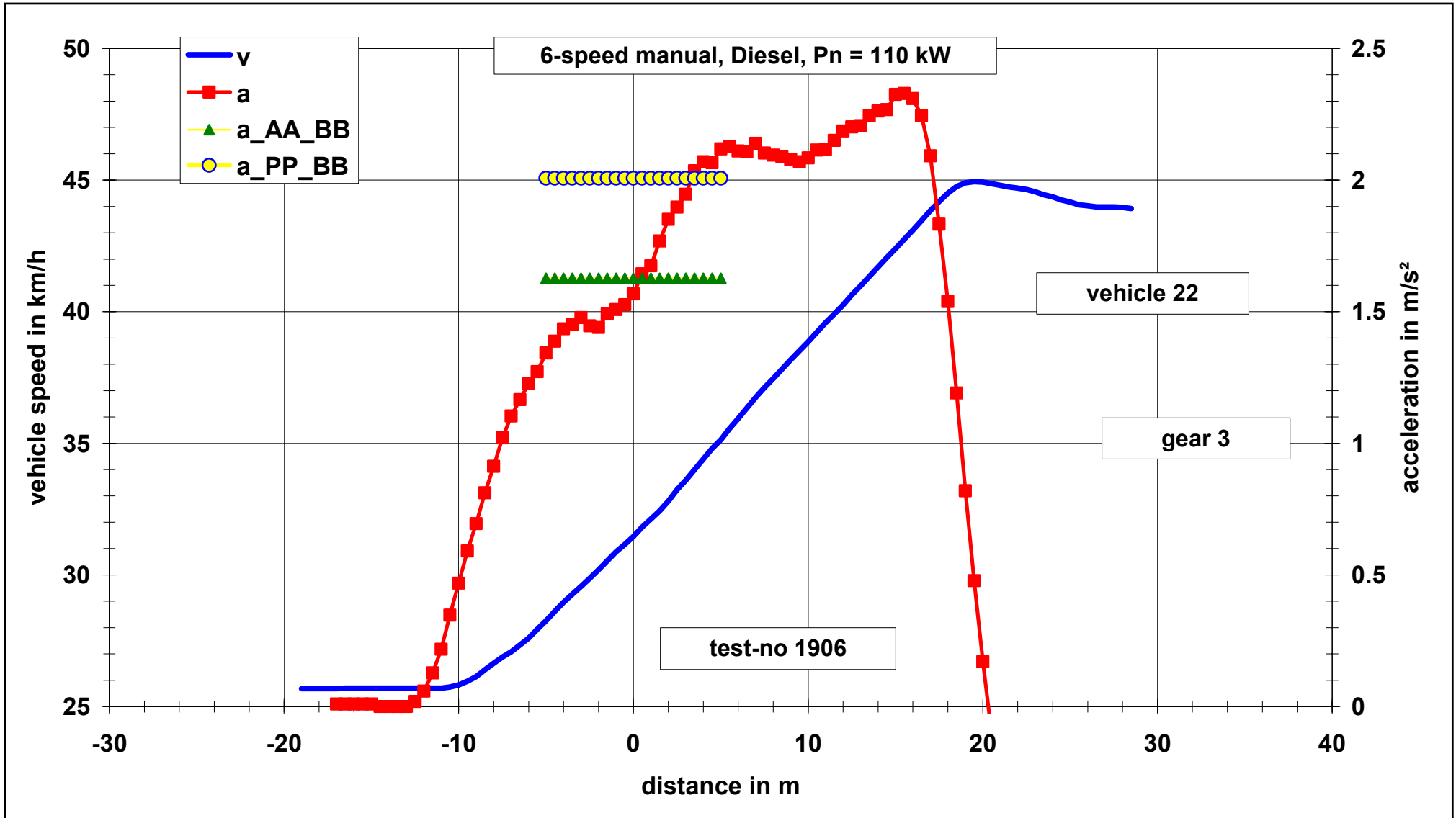
Measurements in 3. Gear showed an increase over the whole track length or an increase over the first 13 m followed by a fluctuating constant value.

Measurements in 4. Gear were similar but with an increase phase of up to 18 m.

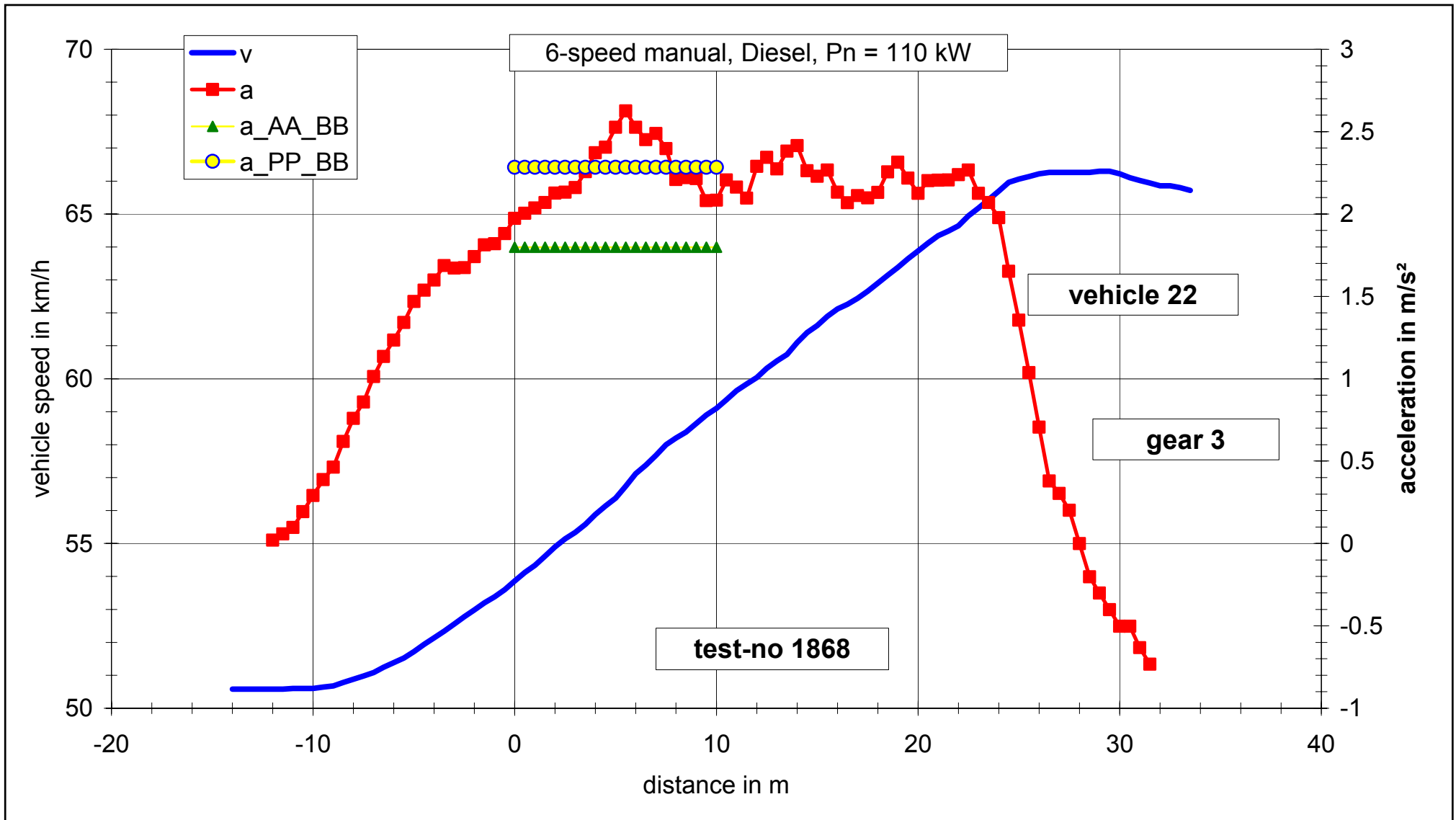
Acceleration Pattern, veh 22, Pn = 110 kW



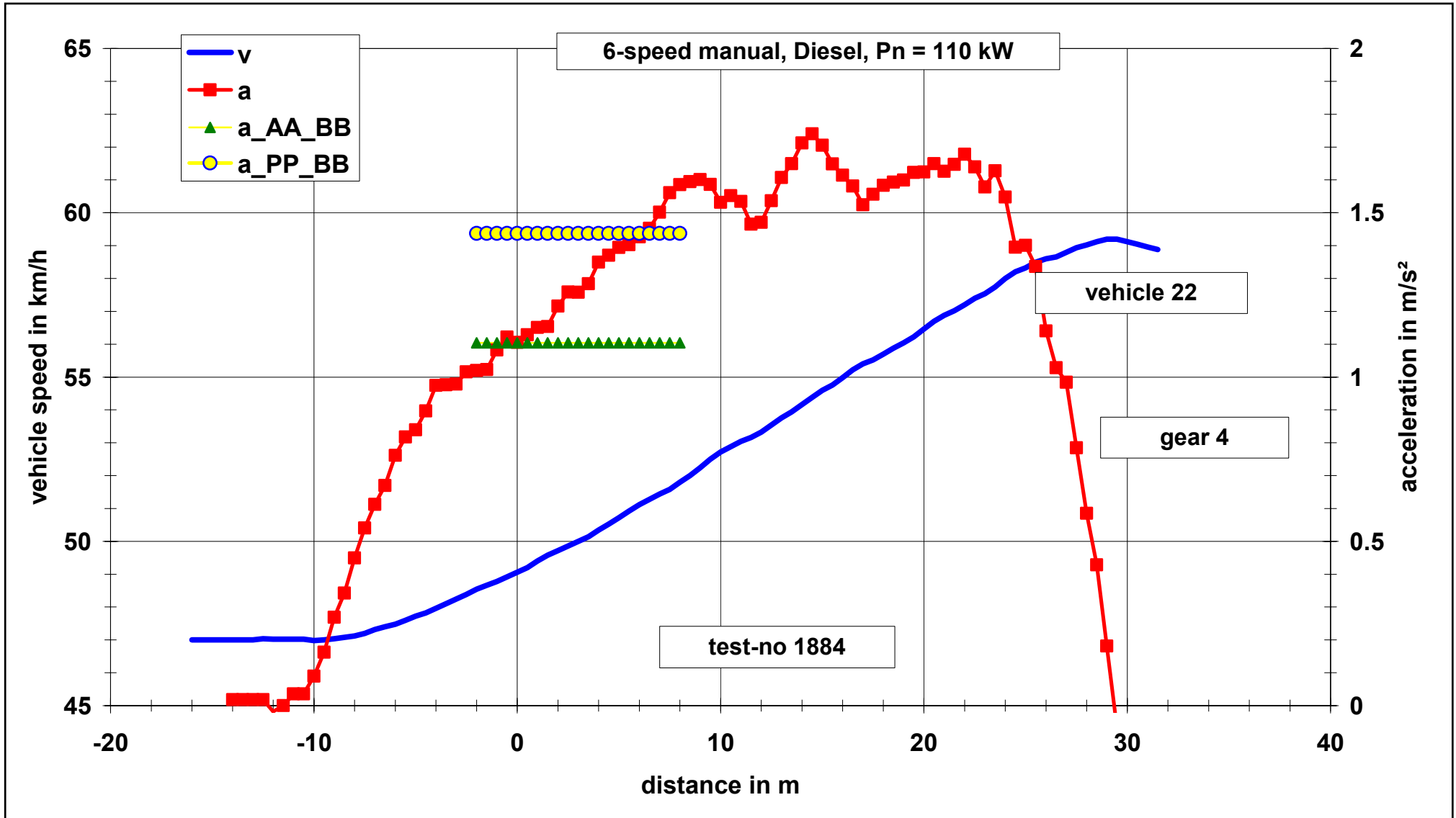
Acceleration Pattern, veh 22, Pn = 110 kW



Acceleration Pattern, veh 22, Pn = 110 kW



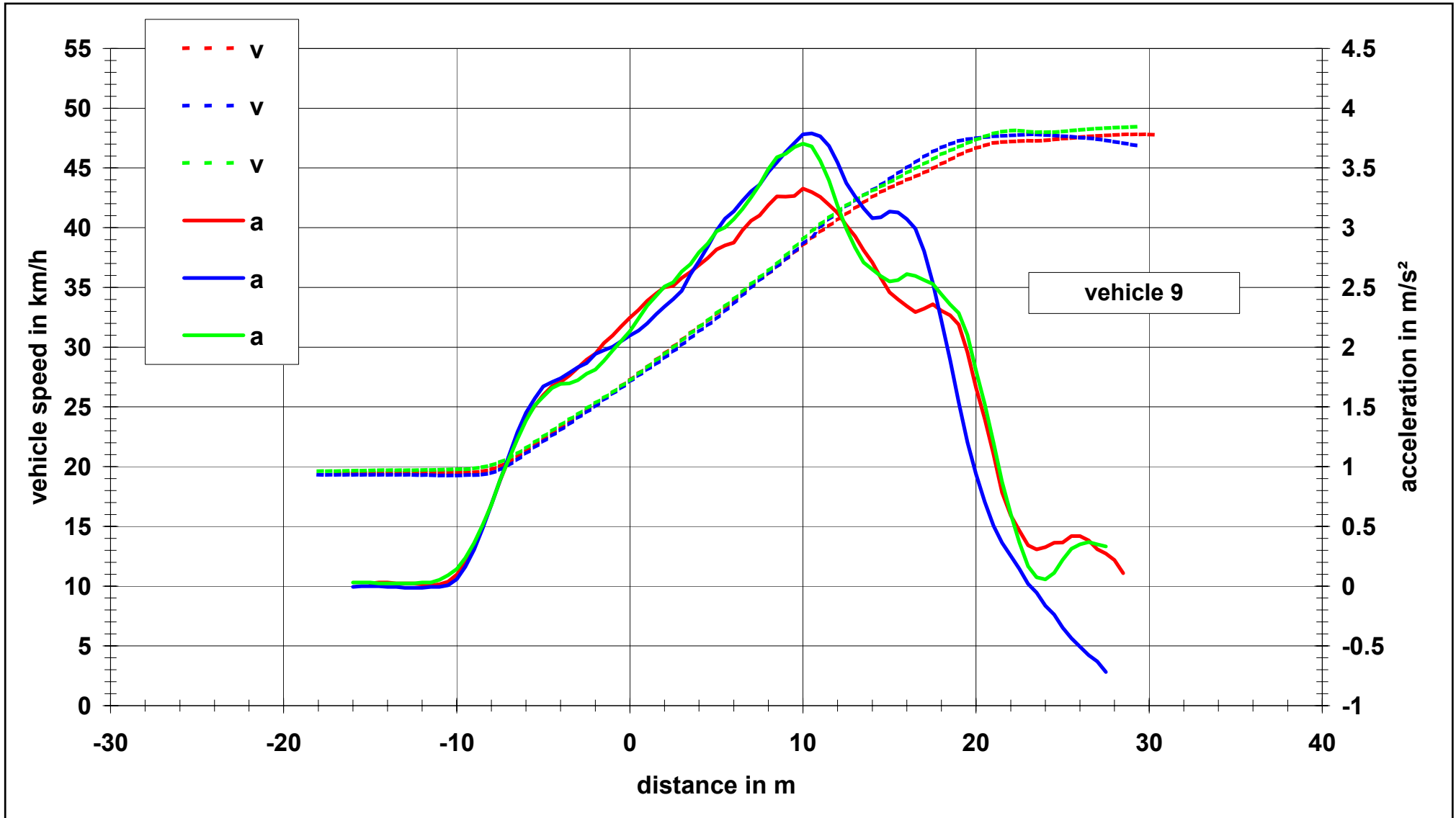
Acceleration Pattern, veh 22, Pn = 110 kW



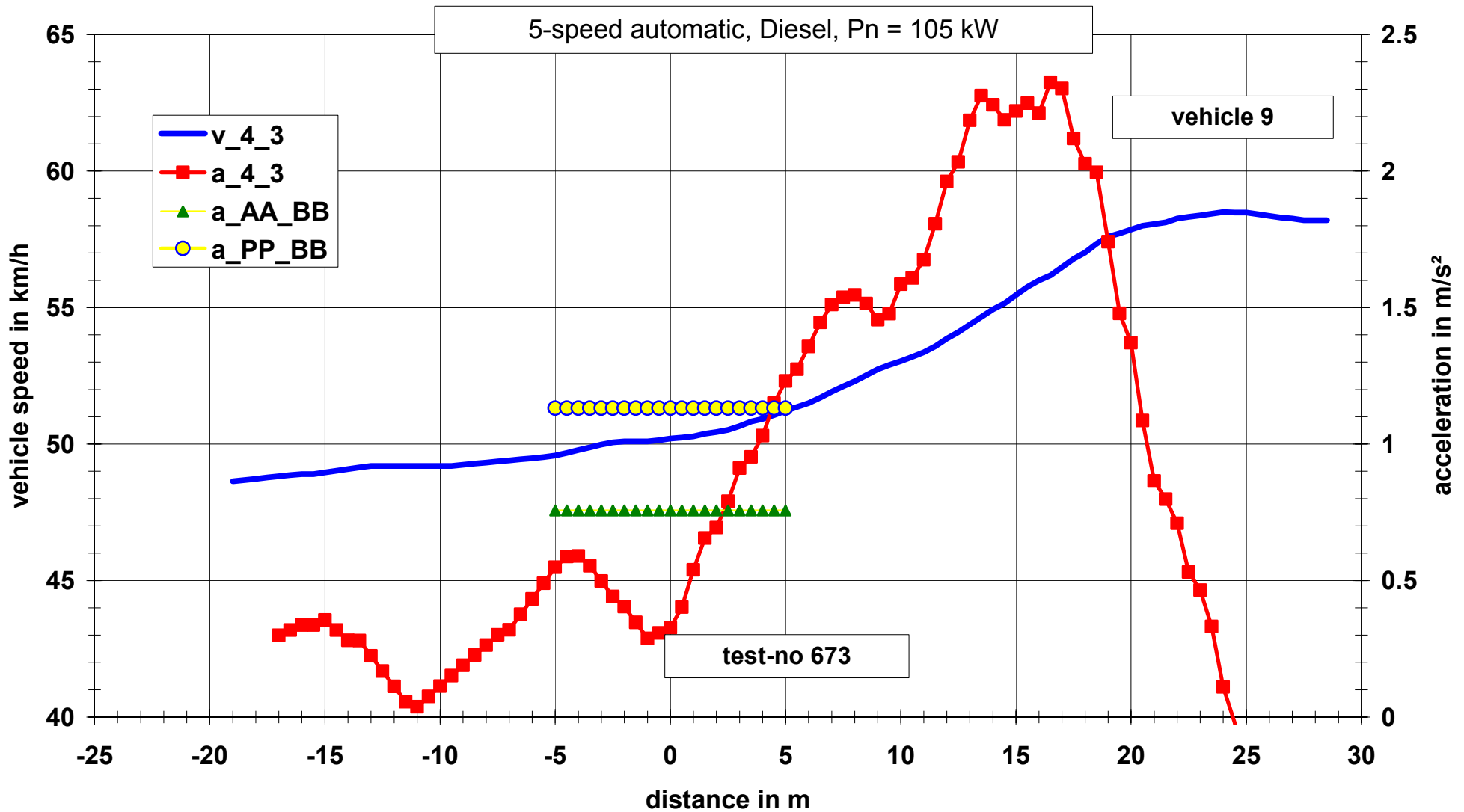
The following figures show the acceleration pattern derived from the speed signal results for a series of driving conditions for vehicles with **automatic transmission**.

- ✓ **Measurements from $v_{AA} = 20$ km/h showed stable and reproducible conditions (gearbox selector in “drive”, no downshift to 1. gear).**
- ✓ **Measurements from $v_{AA} = 50$ km/h:**
 - **in 7 of 10 cases there was a downshift by 1 gear, in 3 of 10 cases there was a downshift by 2 gears. The average acceleration between AA and BB was extreme low in all cases (around 1 m/s^2). The acceleration delay was about 10 m in case of the downshift by 1 gear and about 15 m in case of a downshift by 2 gears.**
 - **Measurements carried out in selector position “3” gave much more reproducible results with a significantly reduced acceleration delay. But even in this case the acceleration increased continuously between AA and BB.**
- ✓ **Measurements for the D/ISO method:**
 - **The target acceleration (related to AA_BB) could not be reached in gear selector position “drive”. So the measurements were carried out in gear selector position “3”. Related to PP_BB the acceleration would meet the target condition in “drive” but with a delay of 10 m.**

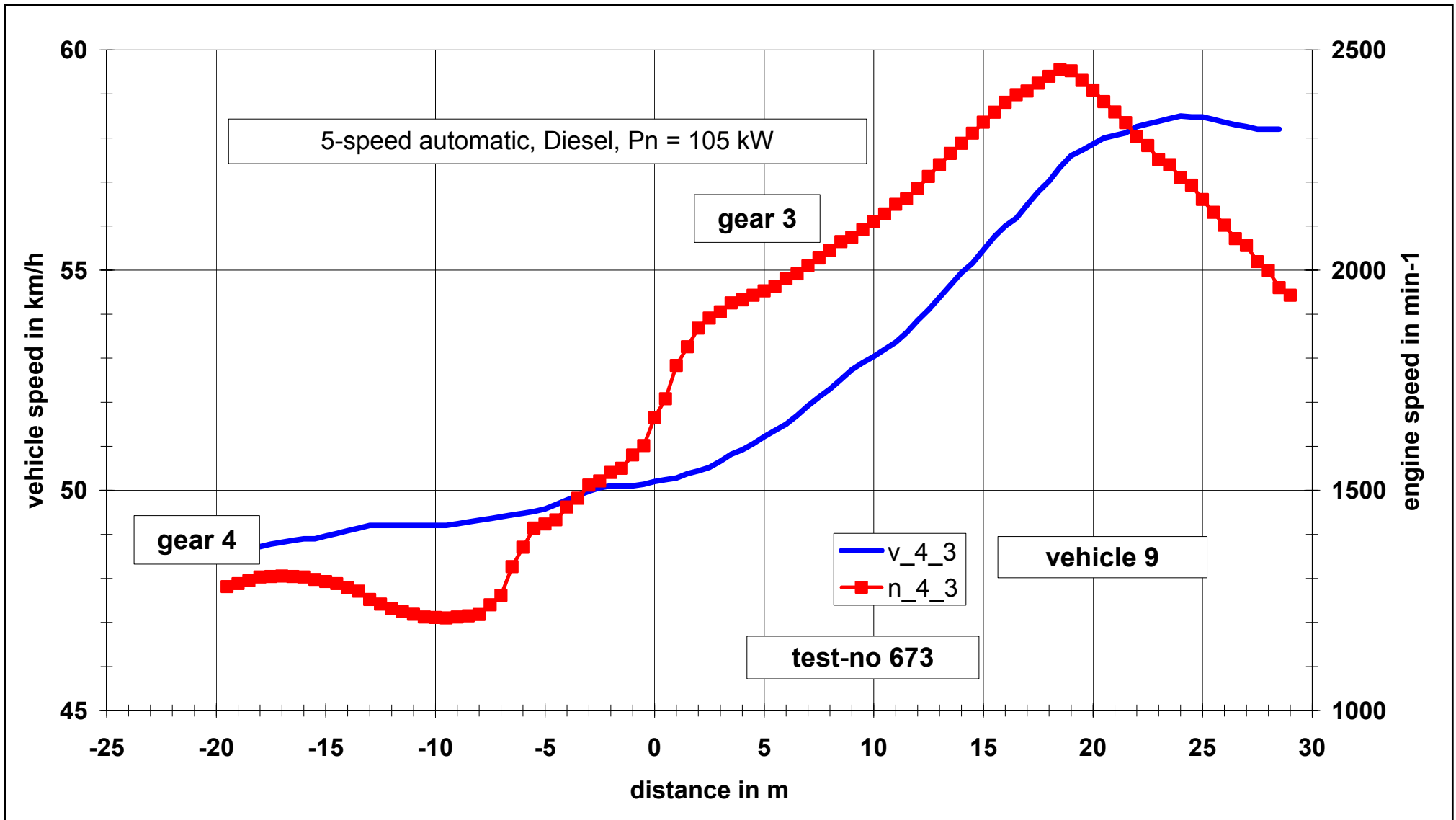
Acceleration Pattern, veh 9, Pn = 105 kW



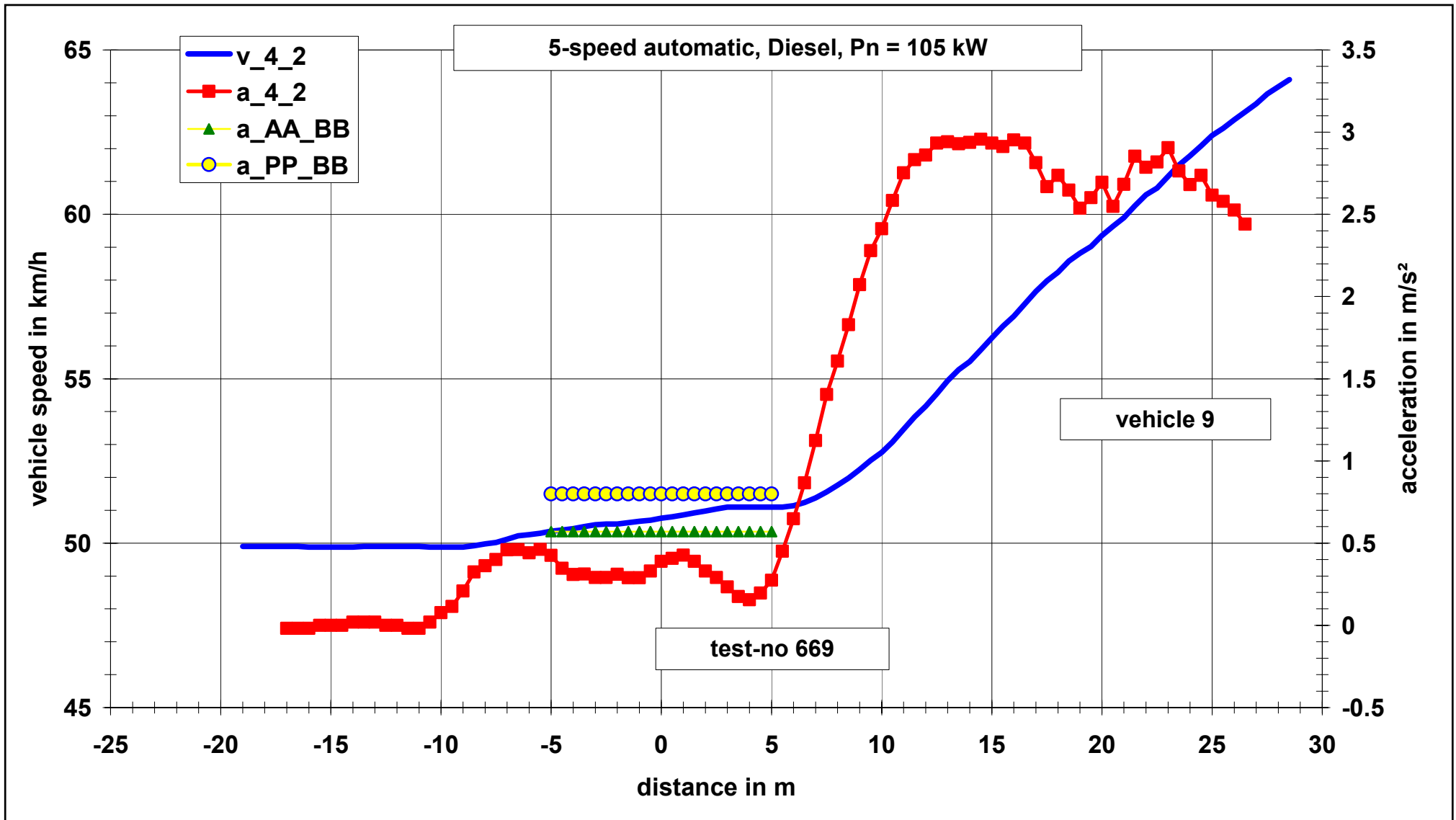
Acceleration Pattern, veh 9, Pn = 105 kW



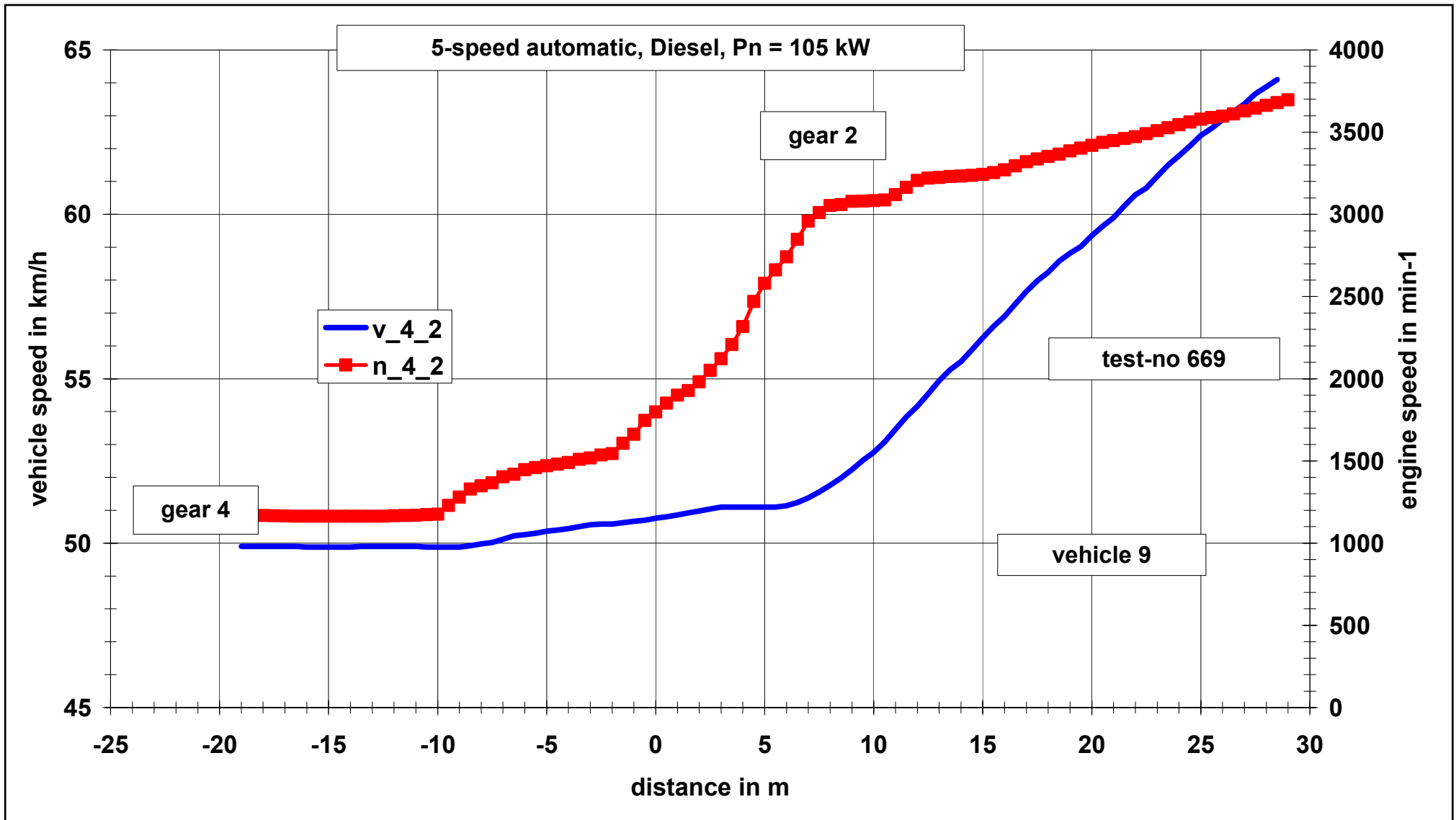
Acceleration Pattern, veh 9, Pn = 105 kW



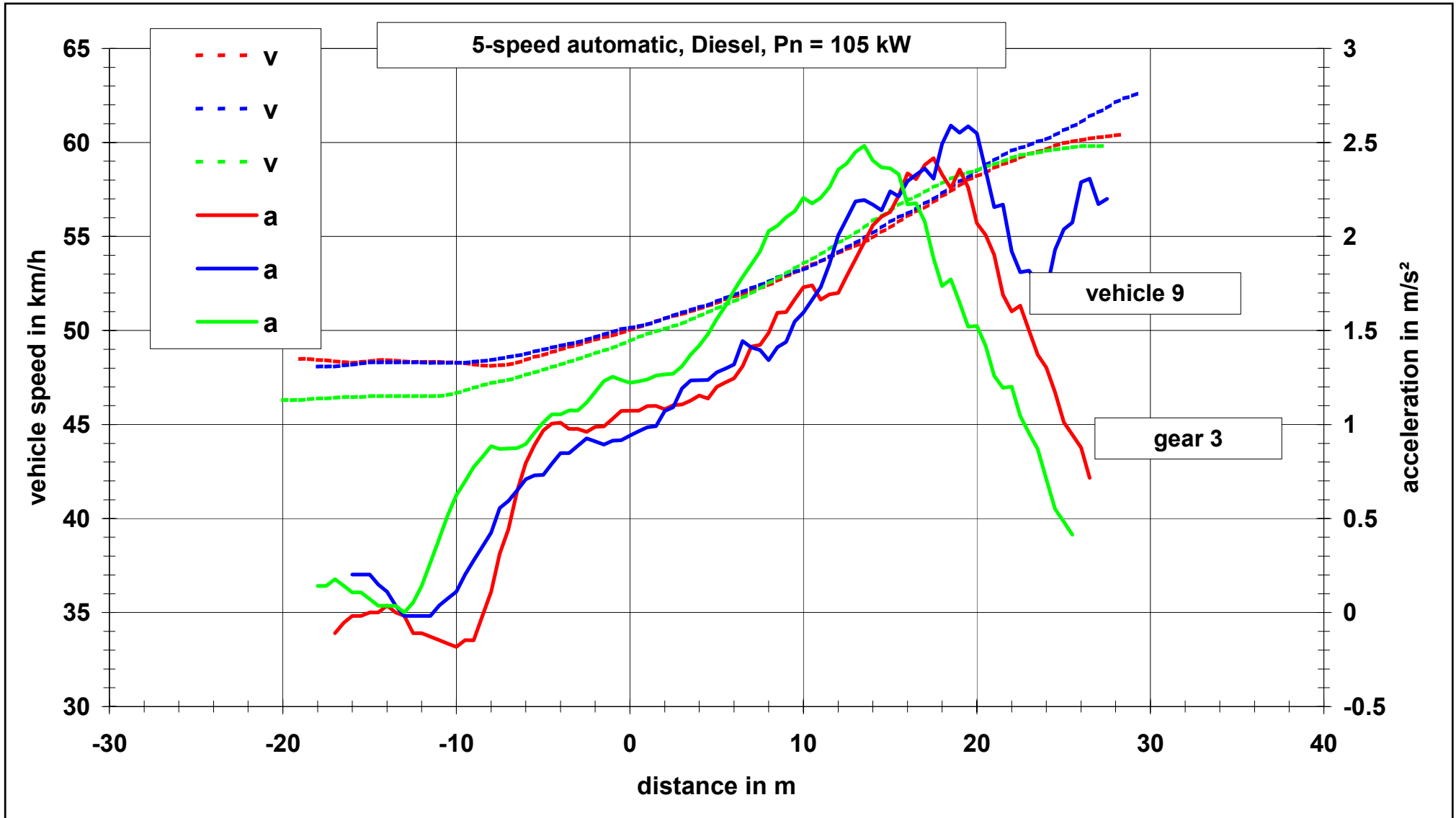
Acceleration Pattern, veh 9, Pn = 105 kW



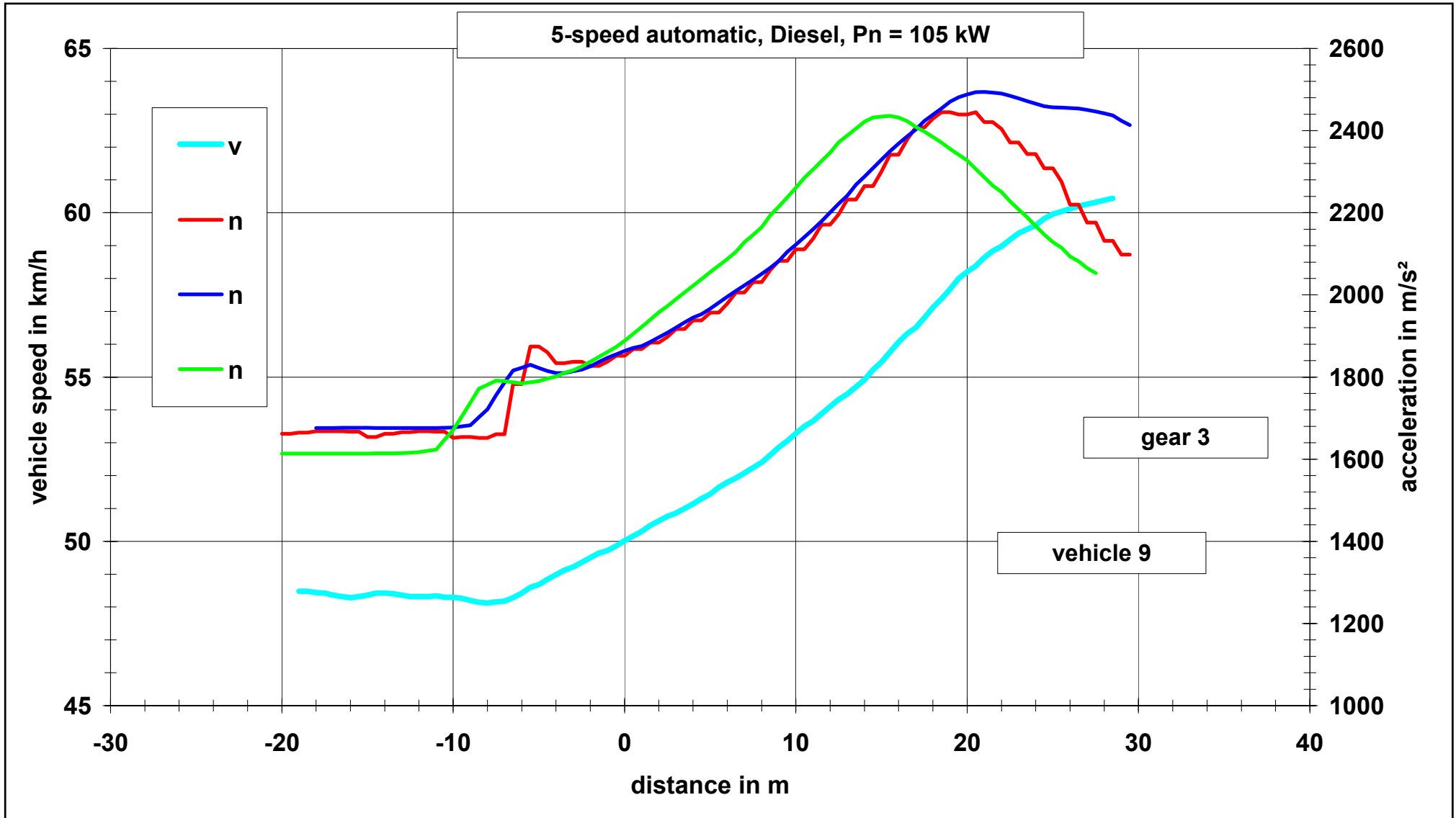
Acceleration Pattern, veh 9, Pn = 105 kW



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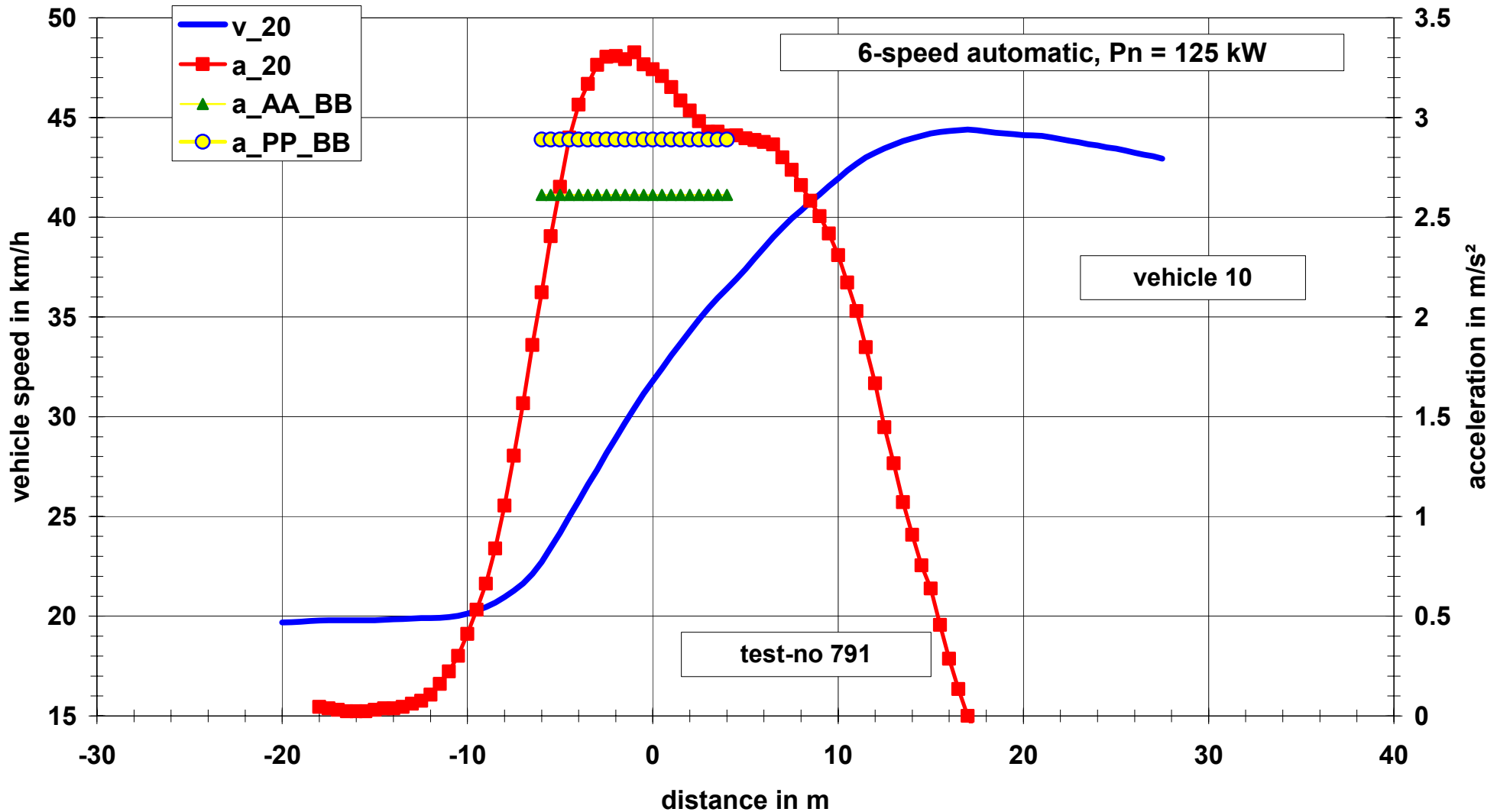


Acceleration Pattern, veh 9, Pn = 105 kW

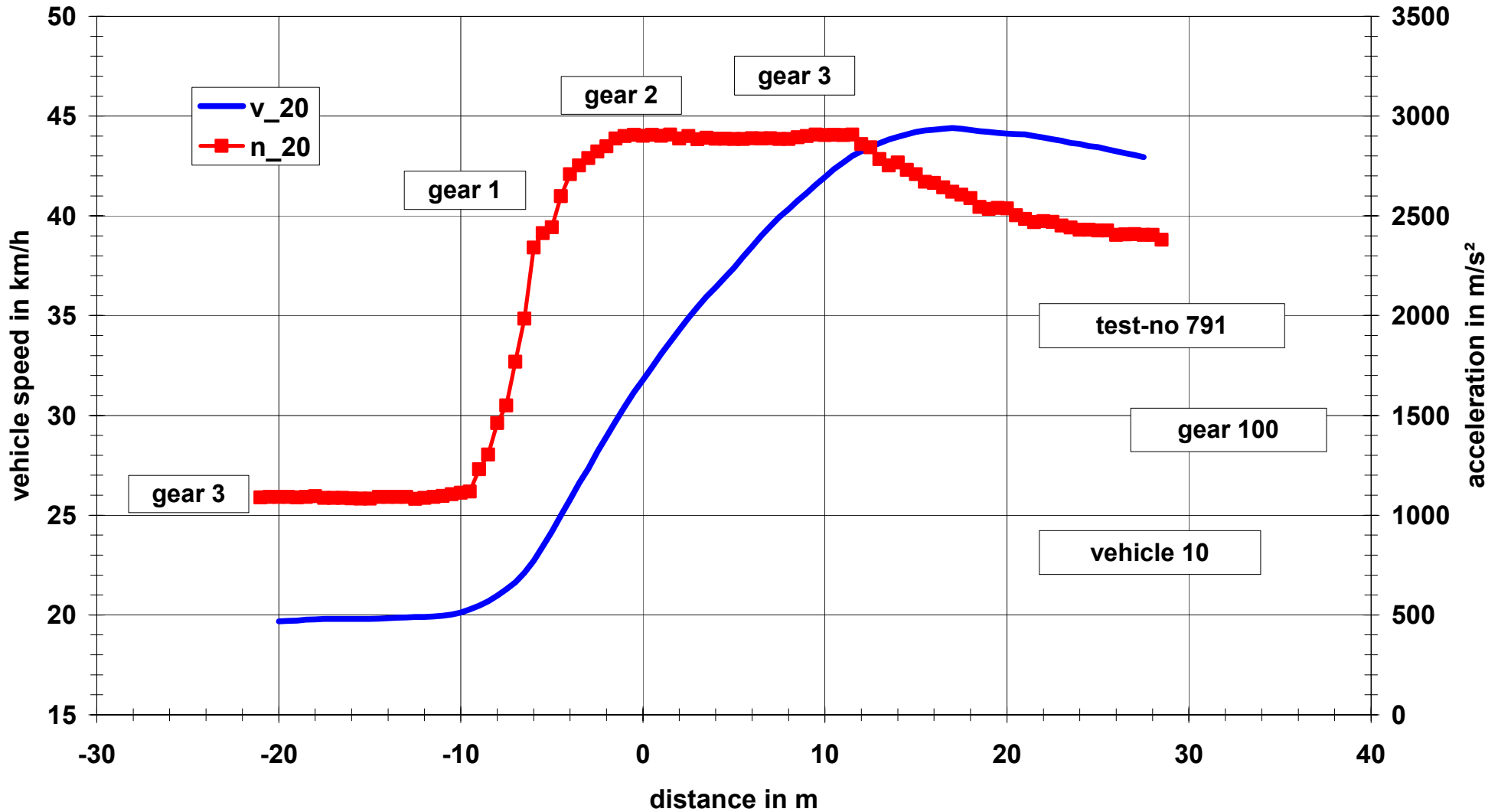


- ✓ **Measurements from $v_{AA} = 20$ km/h** showed stable and reproducible conditions (gearbox selector in “drive”, but downshift to 1. Gear from 3. Gear and upshift to 3. Gear again between AA and BB).
- ✓ **Measurements from $v_{AA} = 50$ km/h:**
 - in all 8 cases there was a downshift by 2 gears (5 to 3). The average acceleration between AA and BB was significantly higher than for other automatics (around 1,25 m/s²) because the acceleration delay was extremely short (below 5 m) although 2 downshifts occurred. The acceleration delay was followed by a nearly steady increase of acceleration up to 2,2 m/s² at BB.
 - Measurements carried out in selector position “3” resulted in a slightly higher acceleration (about 1,35 m/s³) The acceleration pattern were comparable to manual transmissions. The engine speed at BB was lower than in drive because no downshift occurred.
- ✓ **Measurements for the D/ISO method:**
 - The target acceleration (related to AA_BB) could be reached in gear selector position “drive”. The acceleration pattern and downshift behaviour was the same as for the current ECE method.

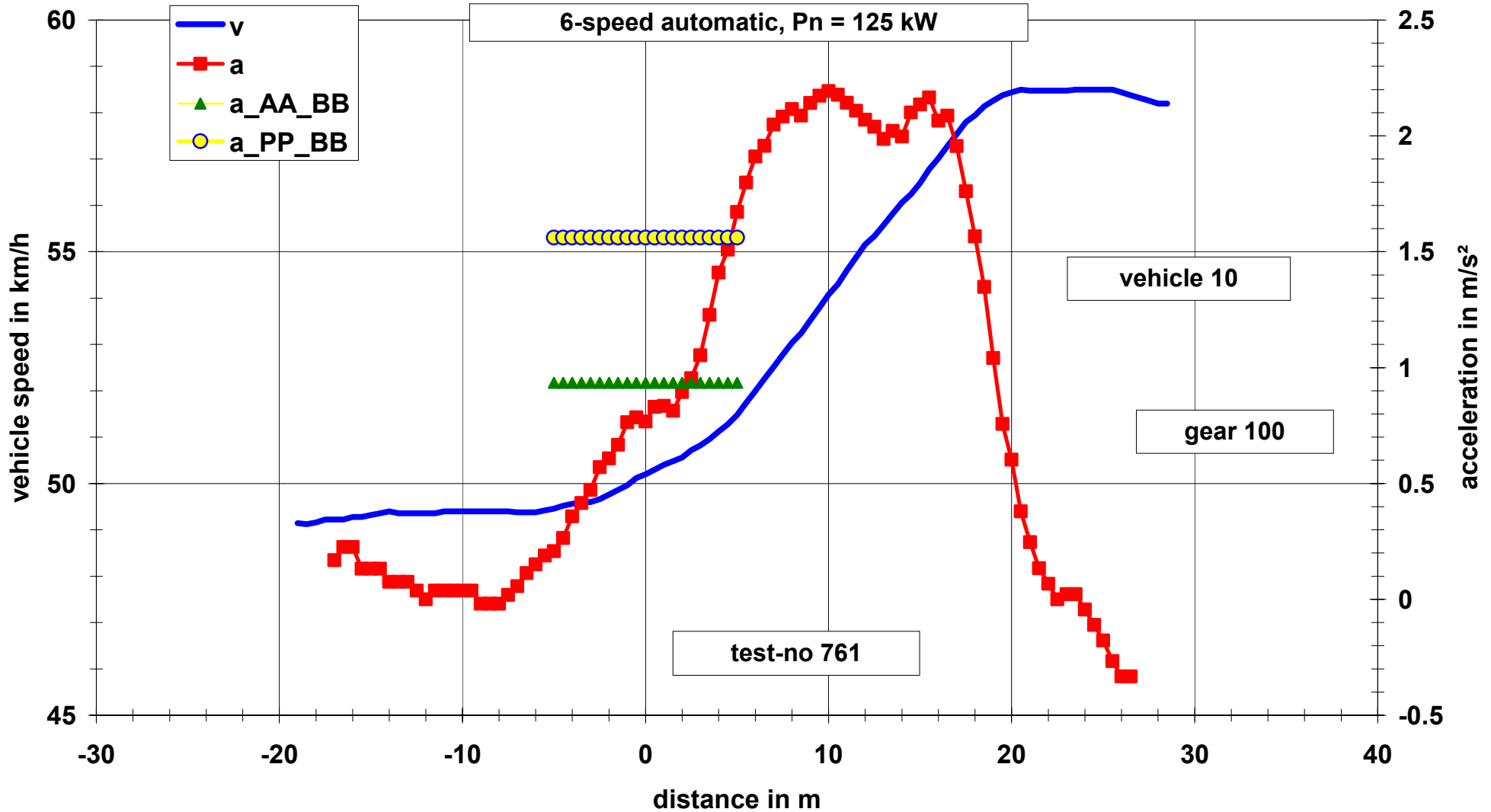
Acceleration Pattern, veh 10, Pn = 125 kW



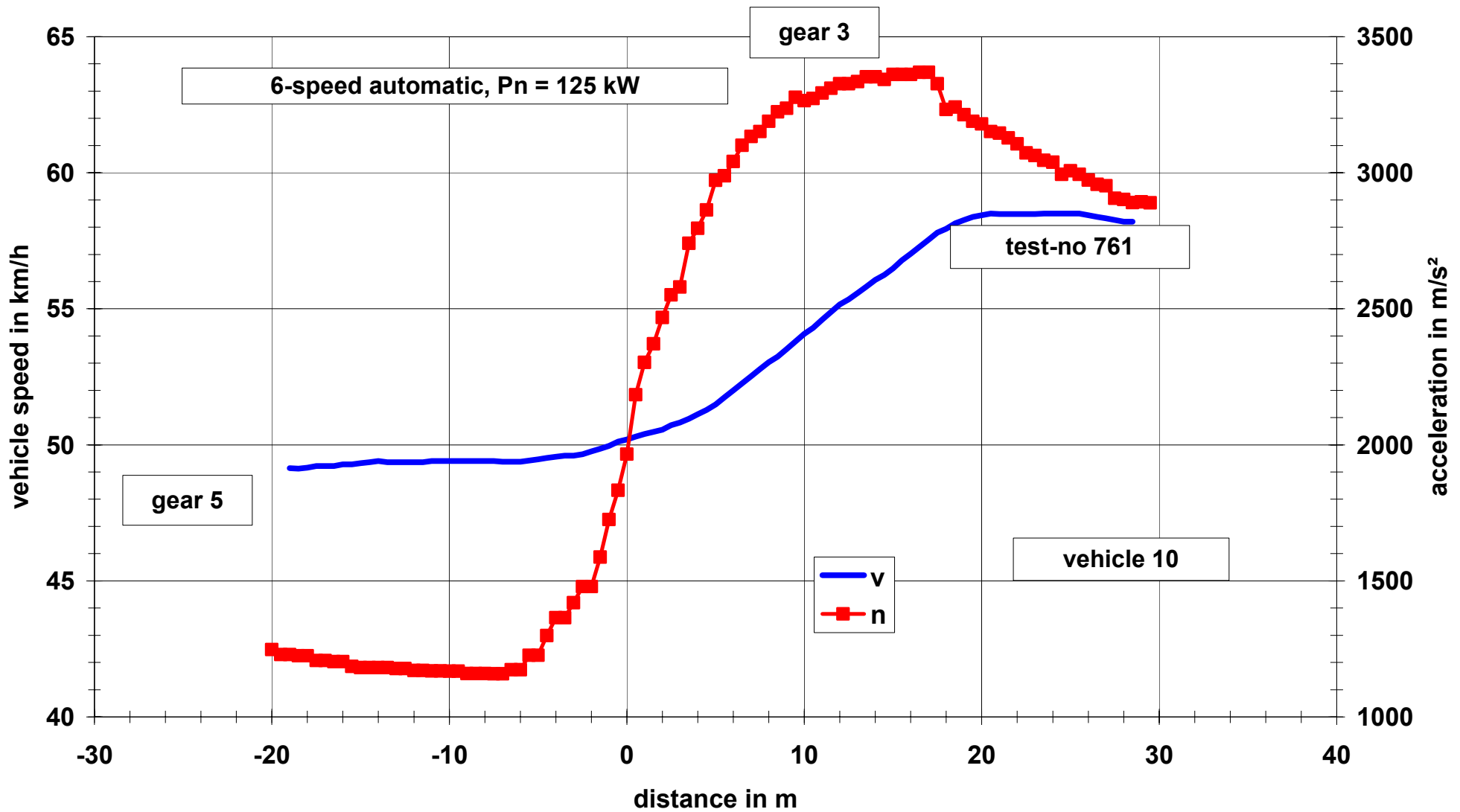
Acceleration Pattern, veh 10, Pn = 125 kW



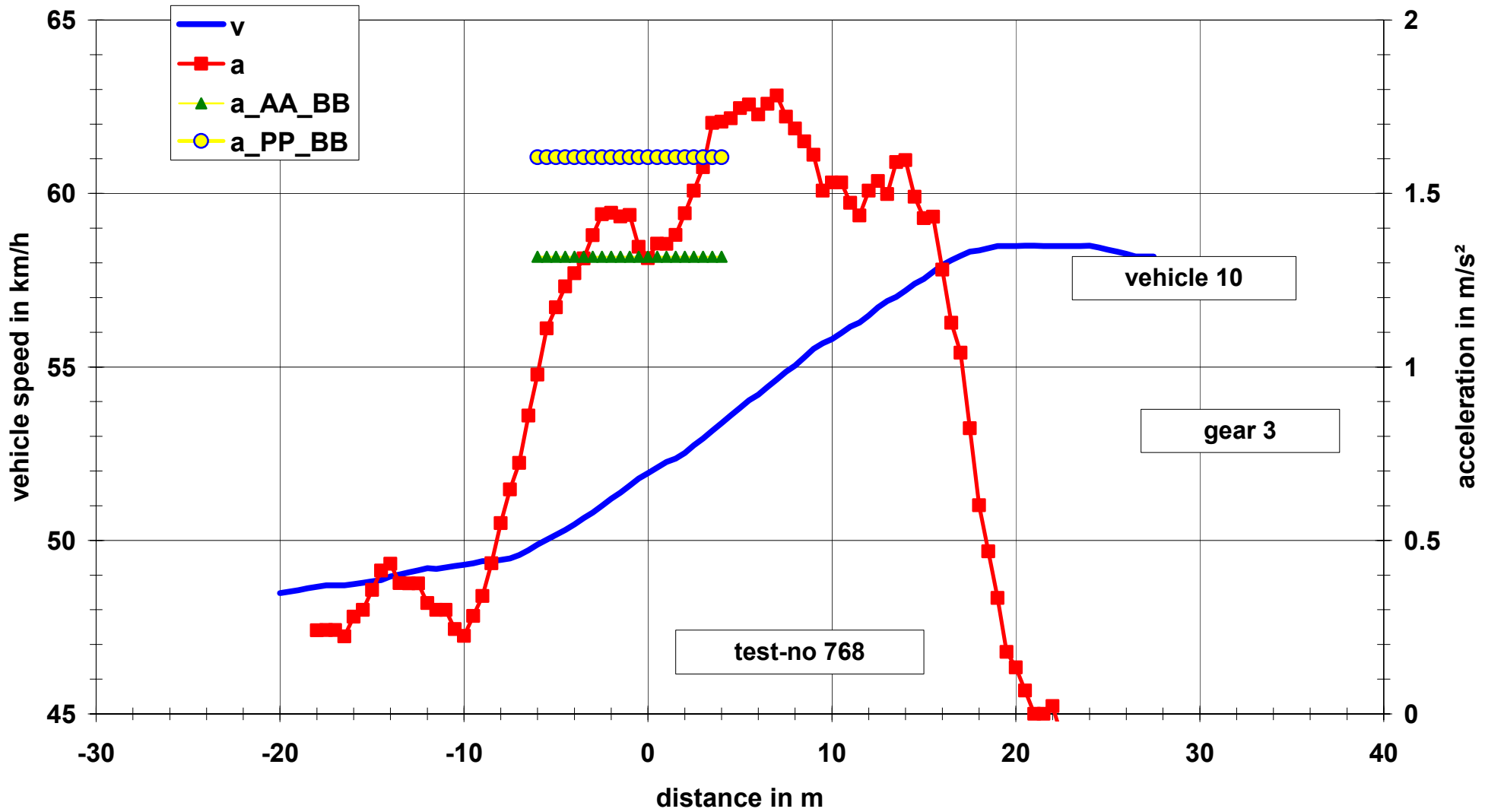
Acceleration Pattern, veh 10, Pn = 125 kW



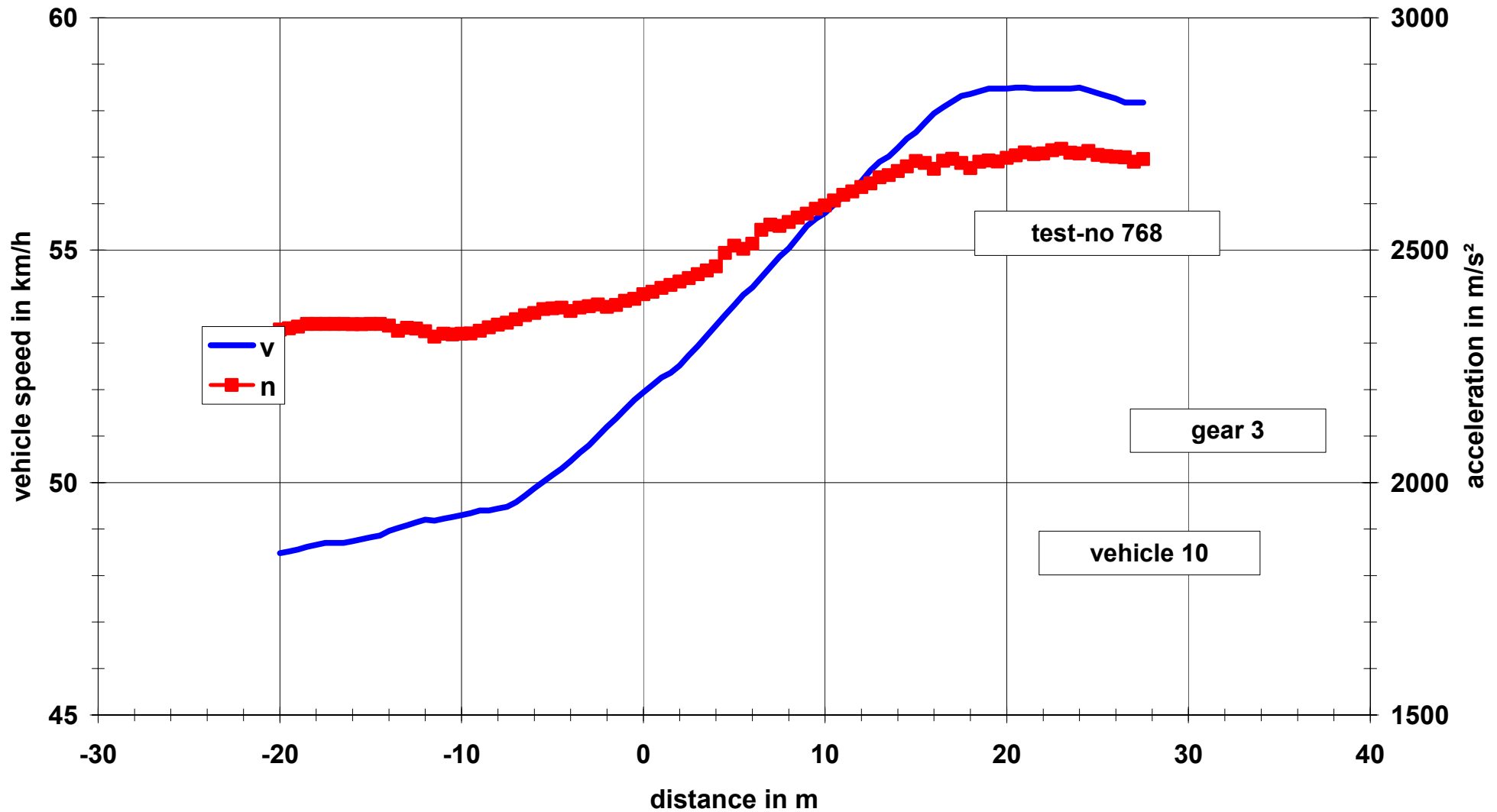
Acceleration Pattern, veh 10, Pn = 125 kW



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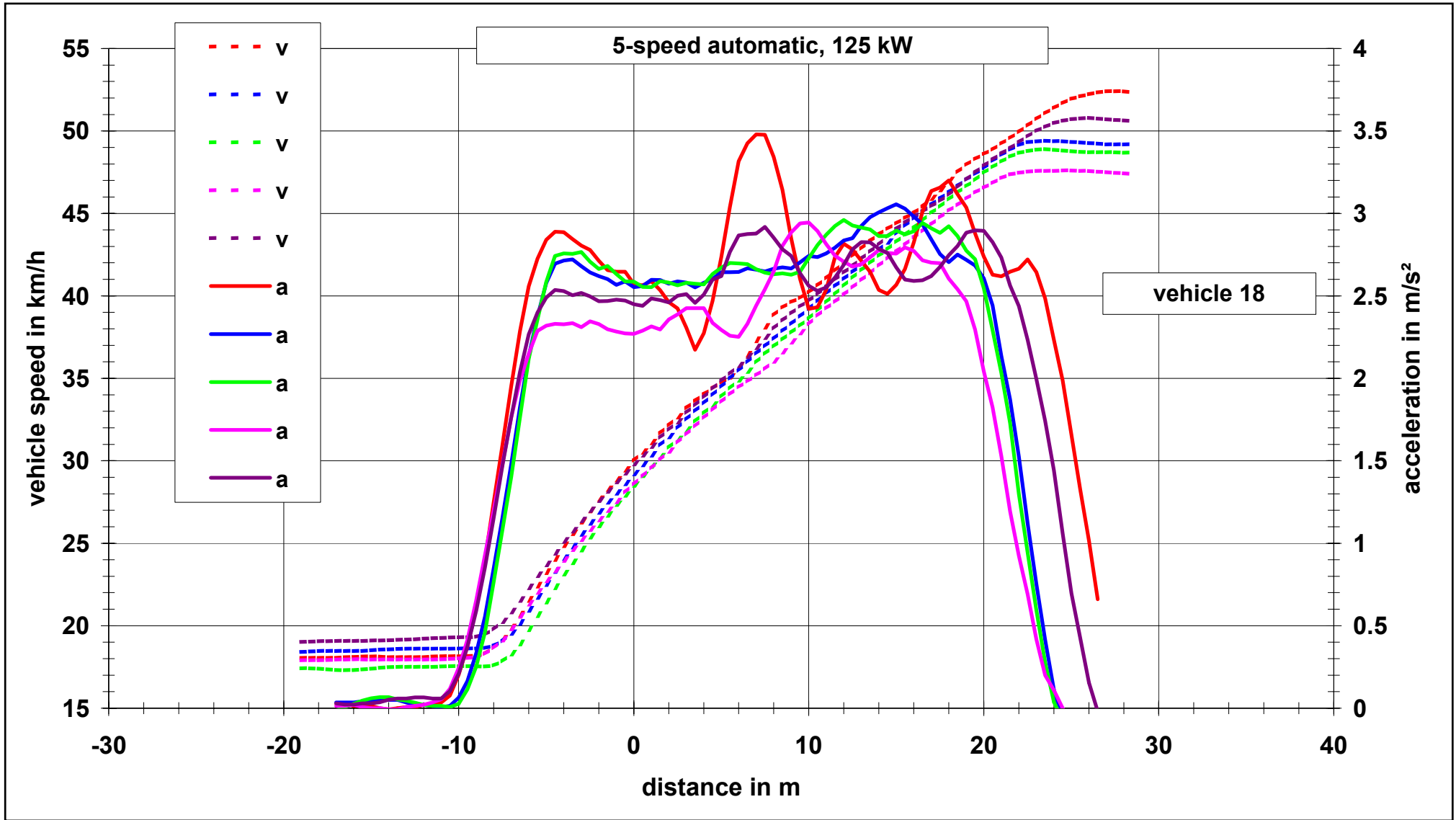


Acceleration Pattern, veh 10, Pn = 125 kW

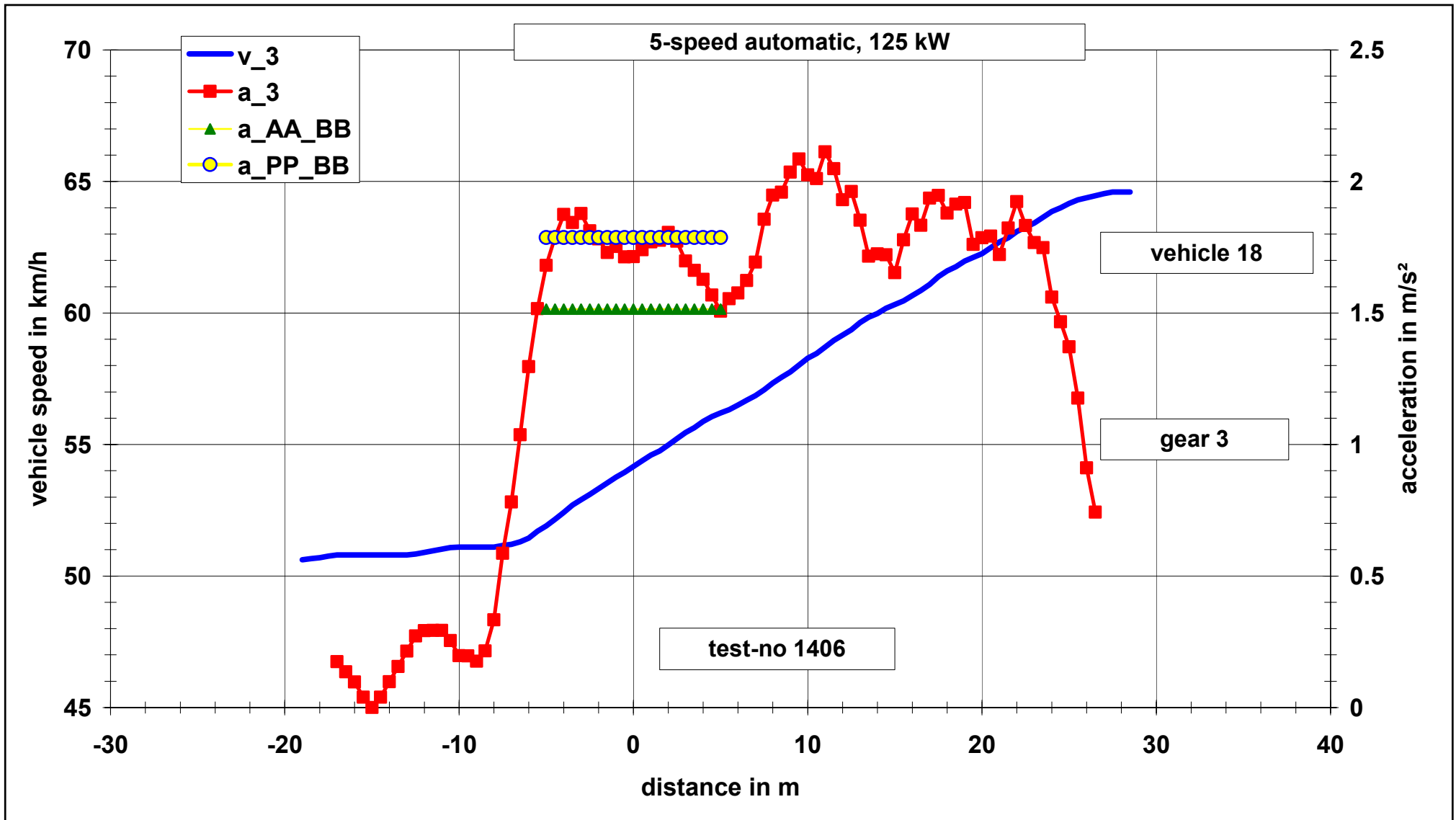


- ✓ **Measurements from $v_{AA} = 20$ km/h showed stable and reproducible conditions (gearbox selector in “drive”, no downshift to 1. gear).**
- ✓ **Measurements from $v_{AA} = 50$ km/h:**
 - in all 8 cases there was a downshift by 1 gear. The average acceleration between AA and BB was extreme low in all cases (around 1 m/s^2 and varied between $0,9 \text{ m/s}^2$ and $1,2 \text{ m/s}^2$). The acceleration delay was about 10 m, followed by a nearly steady increase of acceleration up to 2 m/s^2 at BB.
 - Measurements carried out in selector position “3” resulted in a significantly reduced acceleration delay (about 5 m) The acceleration pattern were comparable to manual transmissions. The average acceleration between AA and BB was $1,55 \text{ m/s}^2$.
- ✓ **Measurements for the D/ISO method:**
 - The target acceleration (related to AA_BB) could not be reached in all 6 runs in gear selector position “drive”. For 3 of these 6 runs there was a downshift by 1 gear (4 to 3) and for the other 3 a downshift by 2 gears (4 to 2). So the measurements were carried out in gear selector position “3”. Related to PP_BB the acceleration would meet the target condition in “drive” but with a delay of 10 m (downshift 4 to 3) or 15 m (downshift 4 to 2) respectively.
 - For 3 of 5 measurements there was a downshift from 3 to 2 even in gear selector position 3. These results were not considered for the D/ISO method because the engine speeds at BB were too high.

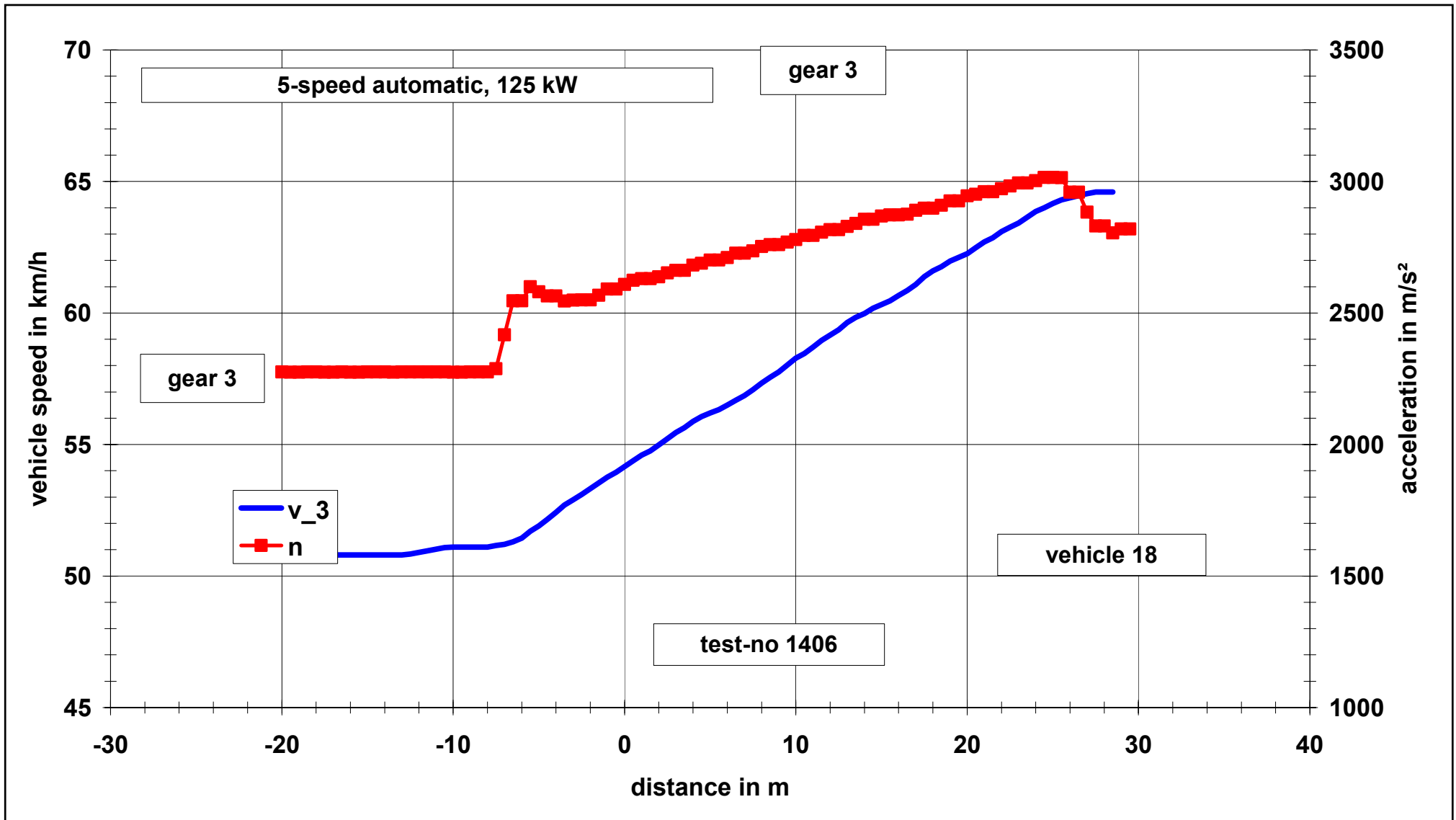
Acceleration Pattern, veh 18, Pn = 125 kW



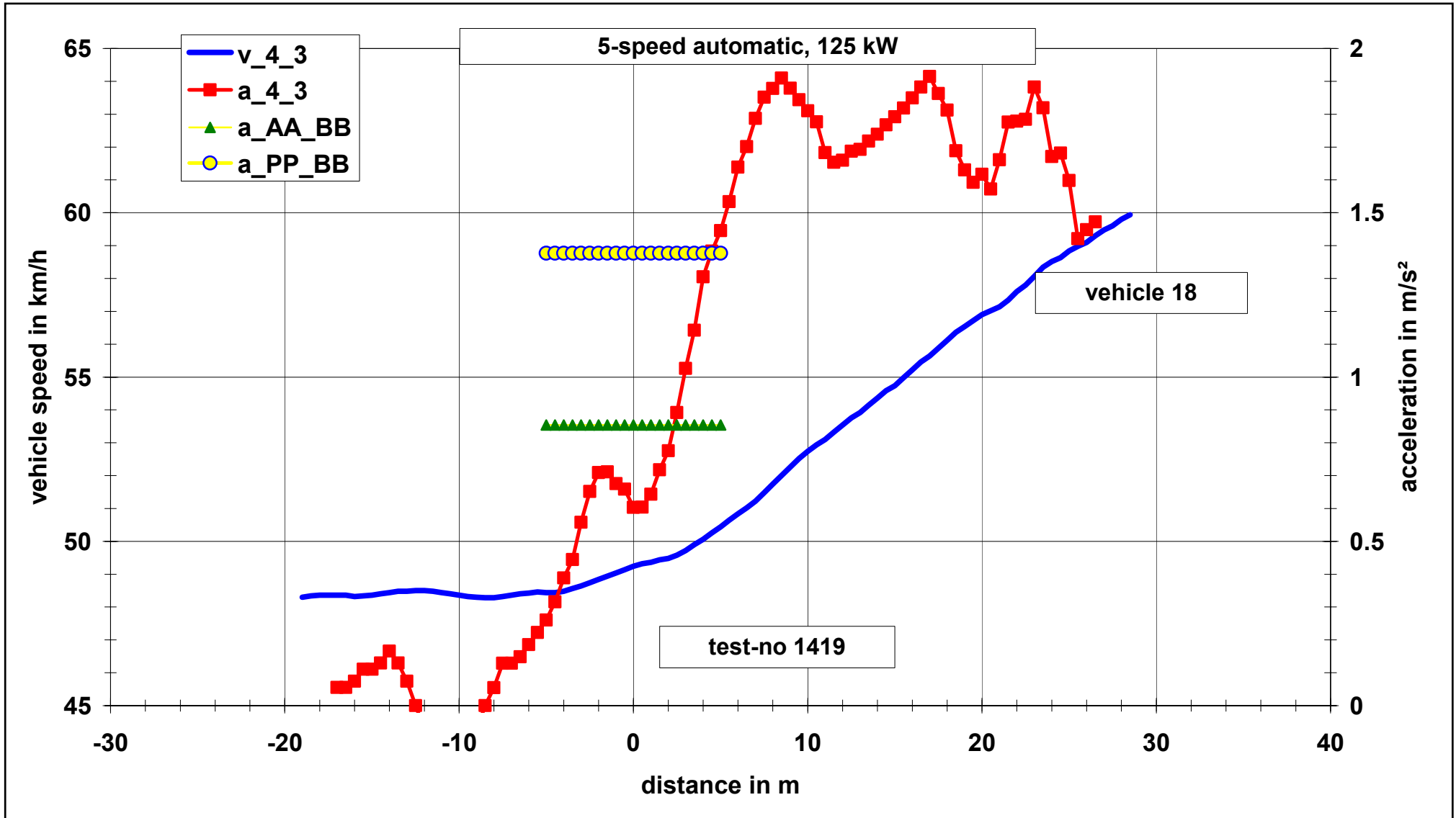
Acceleration Pattern, veh 18, Pn = 125 kW



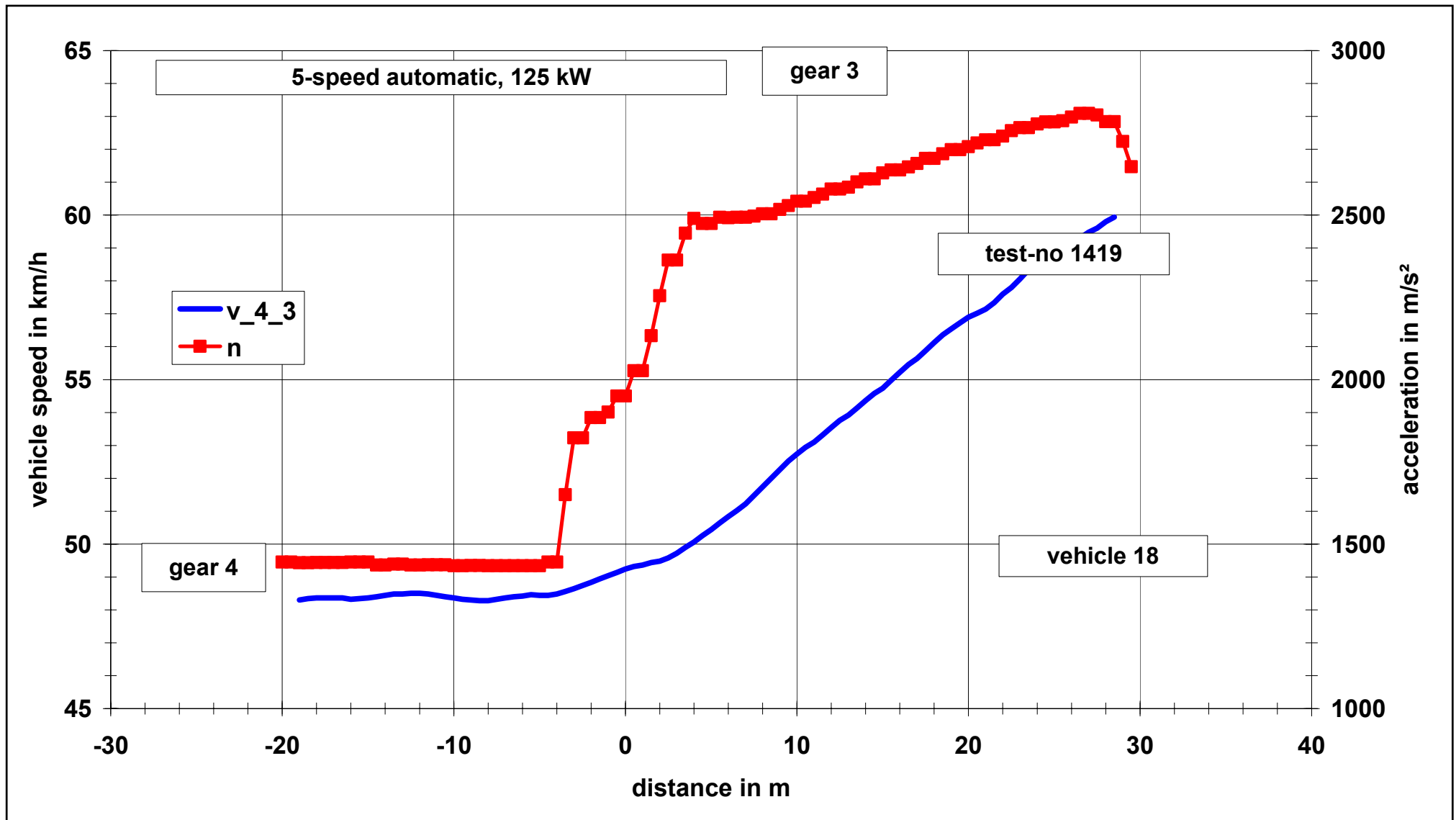
Acceleration Pattern, veh 18, Pn = 125 kW



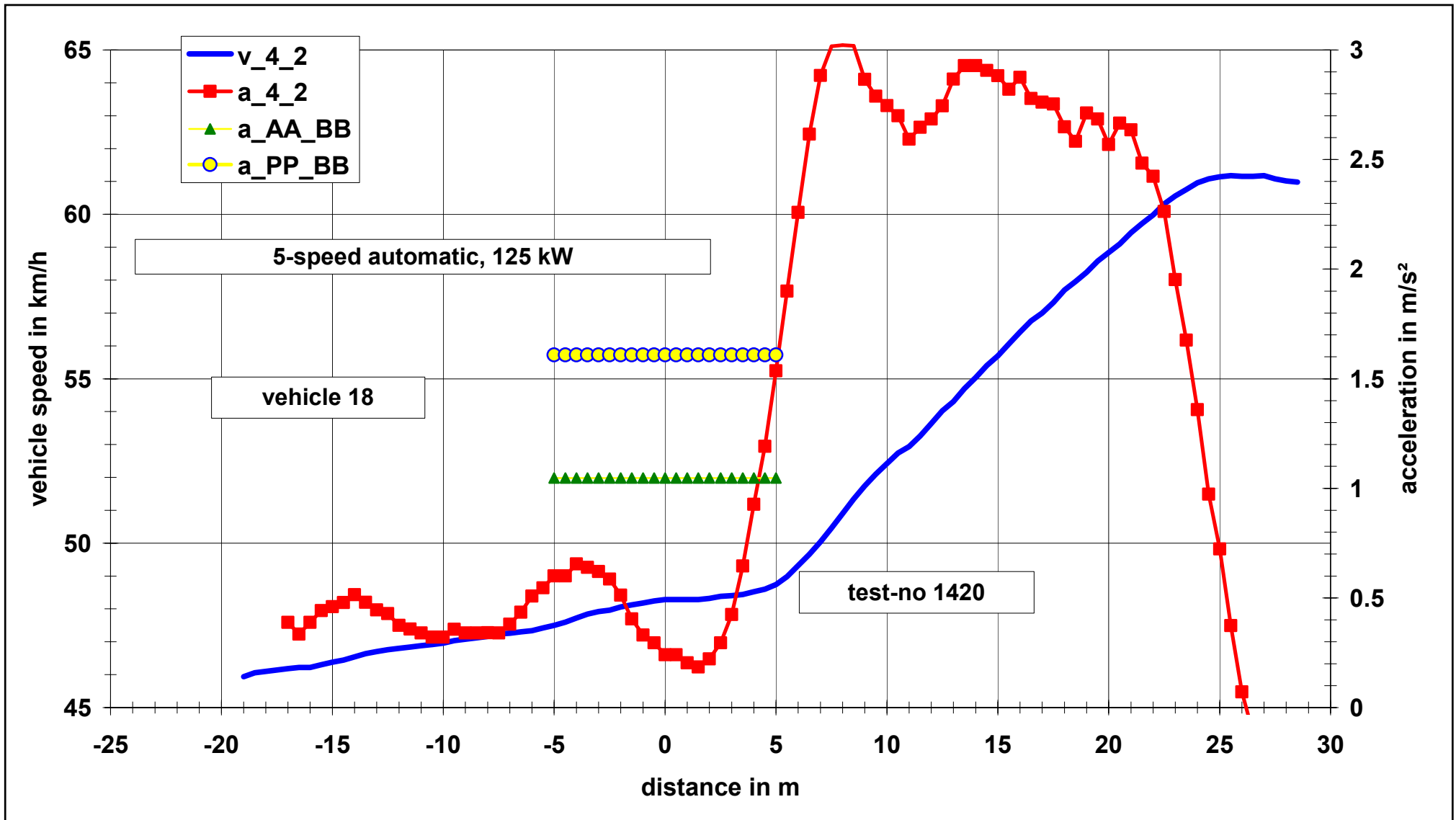
Acceleration Pattern, veh 18, Pn = 125 kW



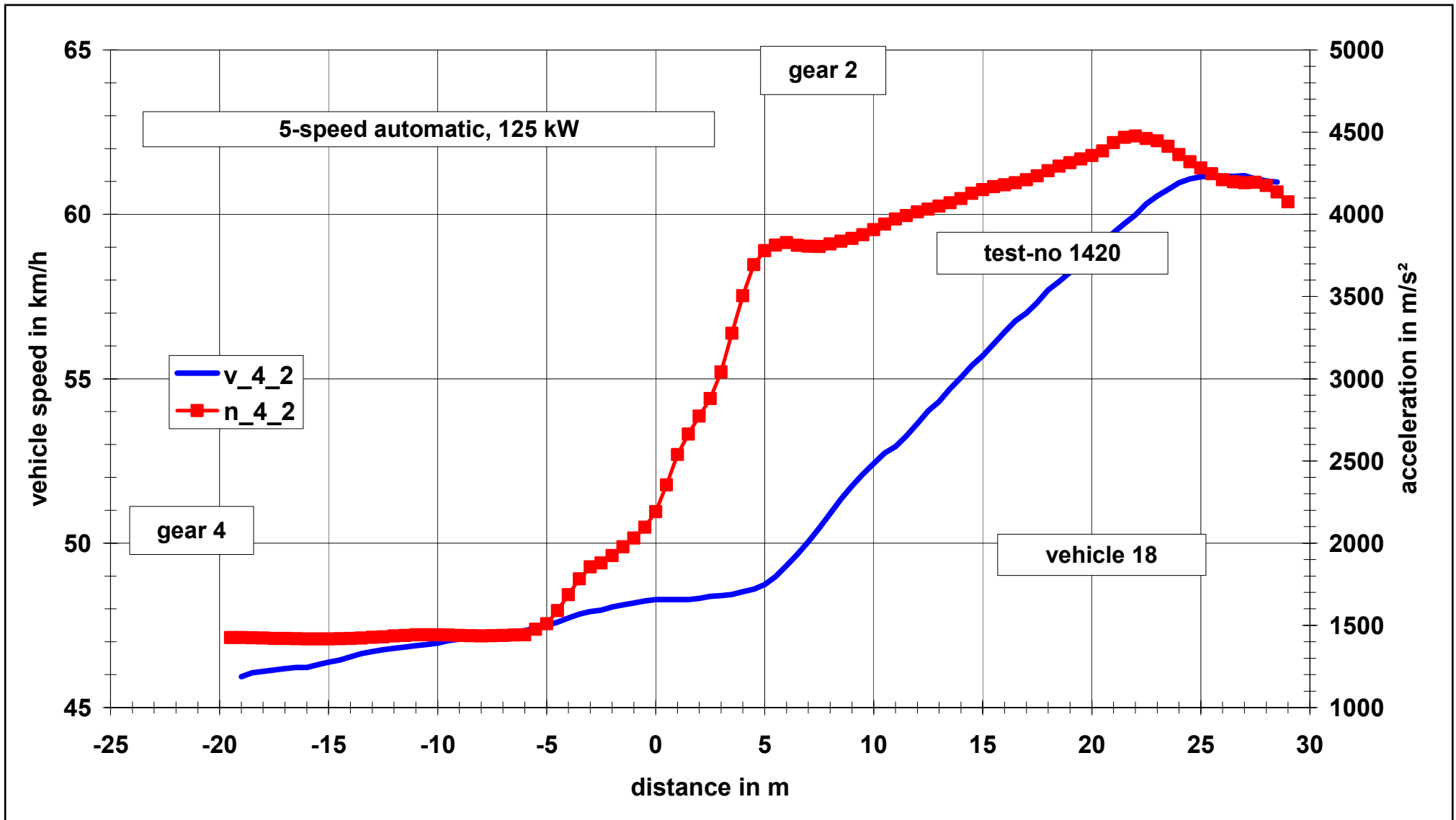
Acceleration Pattern, veh 18, Pn = 125 kW



Acceleration Pattern, veh 18, Pn = 125 kW



Acceleration Pattern, veh 18, Pn = 125 kW



✓ Measurements from $v_{AA} = 20$ km/h:

- Downshift from 2. Gear to 1. Gear with gearbox selector in “drive”. Despite the downshift the acceleration increases over the first 8 m from 0 to 4 m/s² without any significant delay. After that the acceleration decreases slightly with increasing speed. With gear selector in “2” there was no downshift, the steep increase phase was only 5 m, the following decrease phase (15 m) showed modulations.

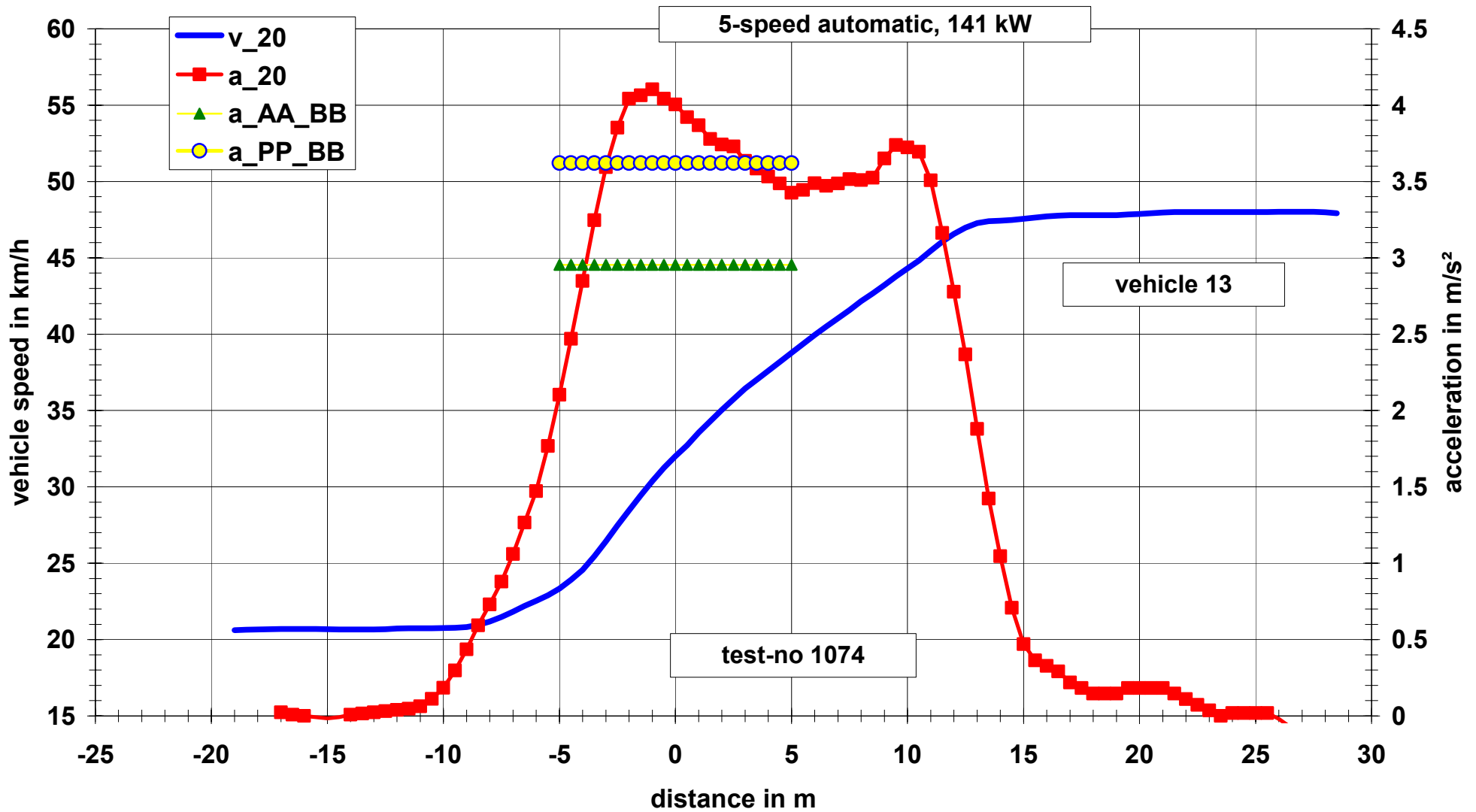
✓ Measurements from $v_{AA} = 50$ km/h:

- in 5 of 10 cases there was a downshift from gear 4 to gear 2, in 4 of 10 cases the downshift was from gear 4 to gear 3 and in 1 case from gear 3 to gear 2. The average acceleration between AA and BB was extreme low in all cases (around 1 m/s²). The acceleration delay was about 5 m to 7 m in case of the downshift by 1 gear and about 12 m in case of a downshift by 2 gears.
- Measurements carried out in selector position “3” gave much more reproducible results with a significantly reduced acceleration delay. In this case the acceleration pattern looks similar to manual transmission vehicles but with an increase from -10 m to 0 m and a decrease from 0 m to 10 m.

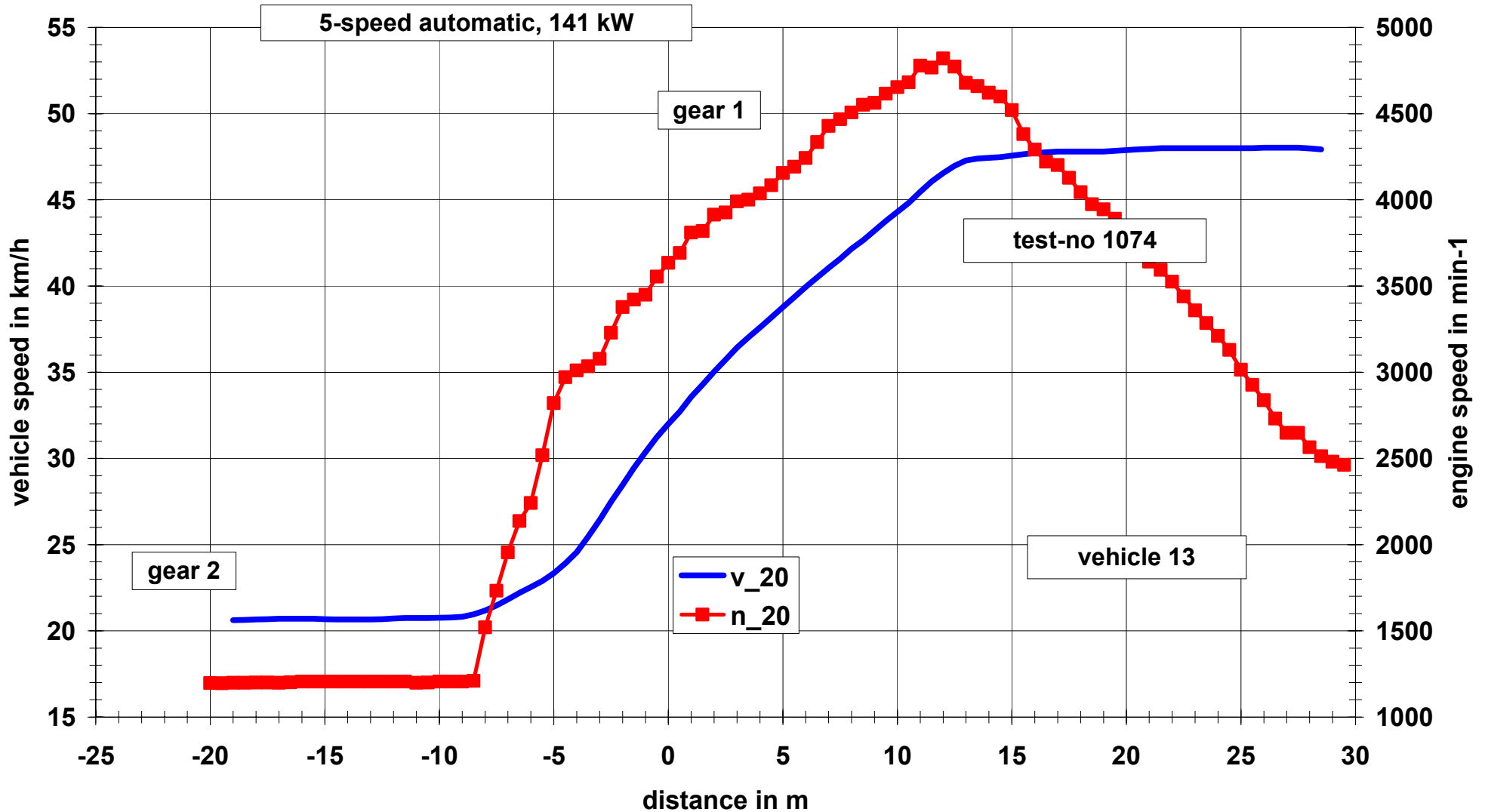
✓ Measurements for the D/ISO method:

- The target acceleration (related to AA_BB) was reached in gear selector position “drive”. In all cases there was a downshift from gear 4 to gear 2 with an acceleration delay of 10 m.

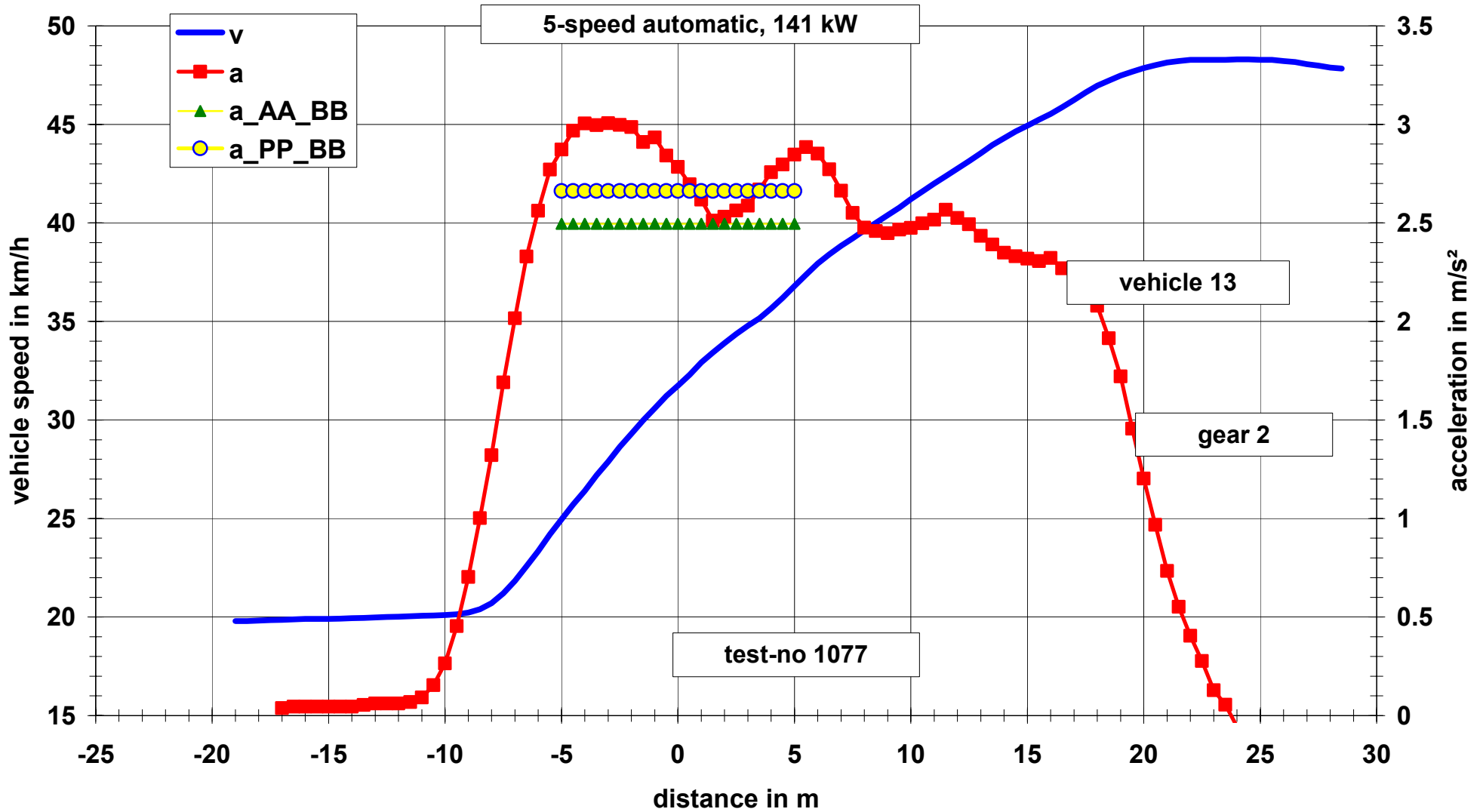
Acceleration Pattern, veh 13, Pn = 141 kW



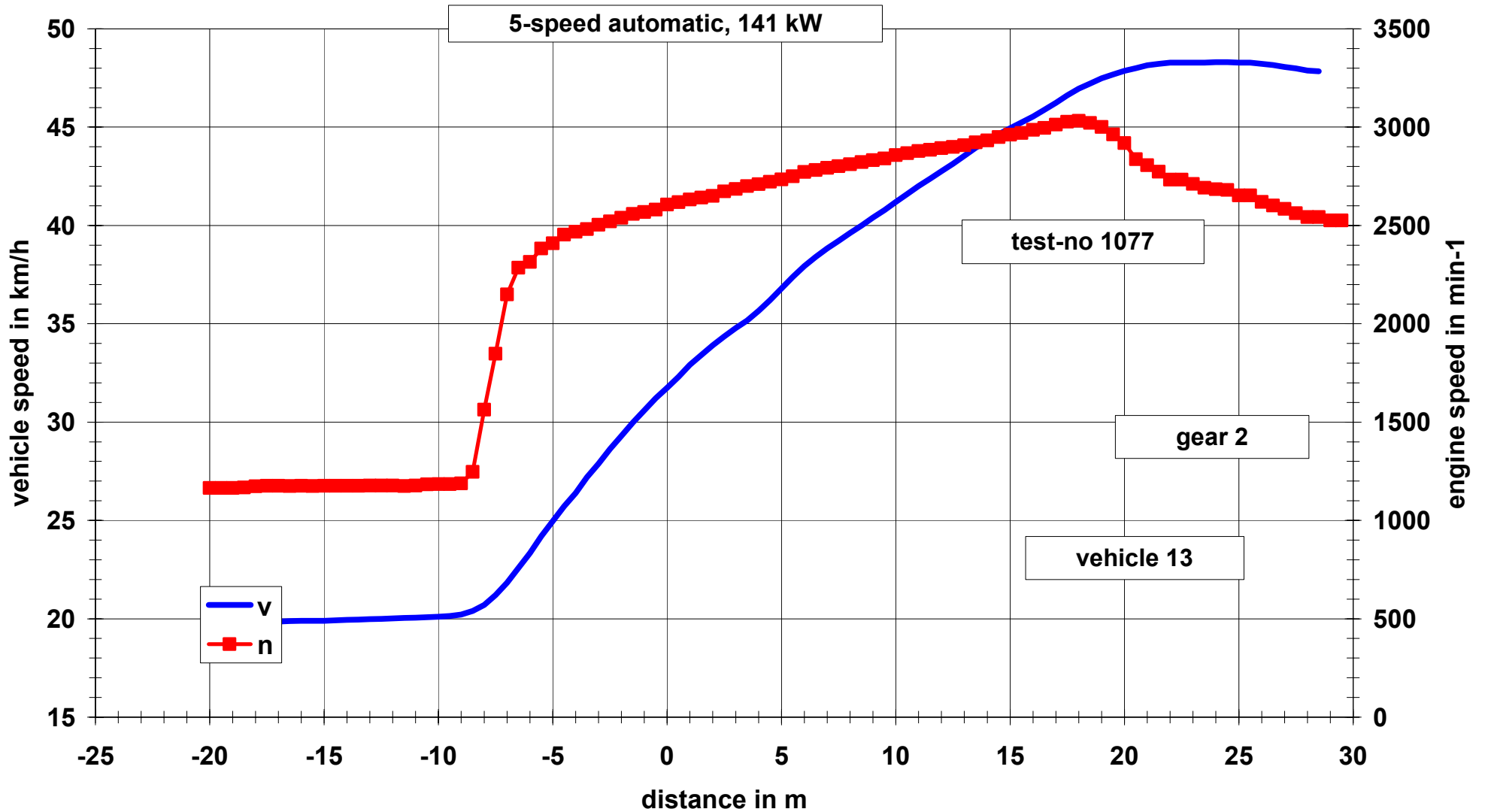
Acceleration Pattern, veh 13, Pn = 141 kW



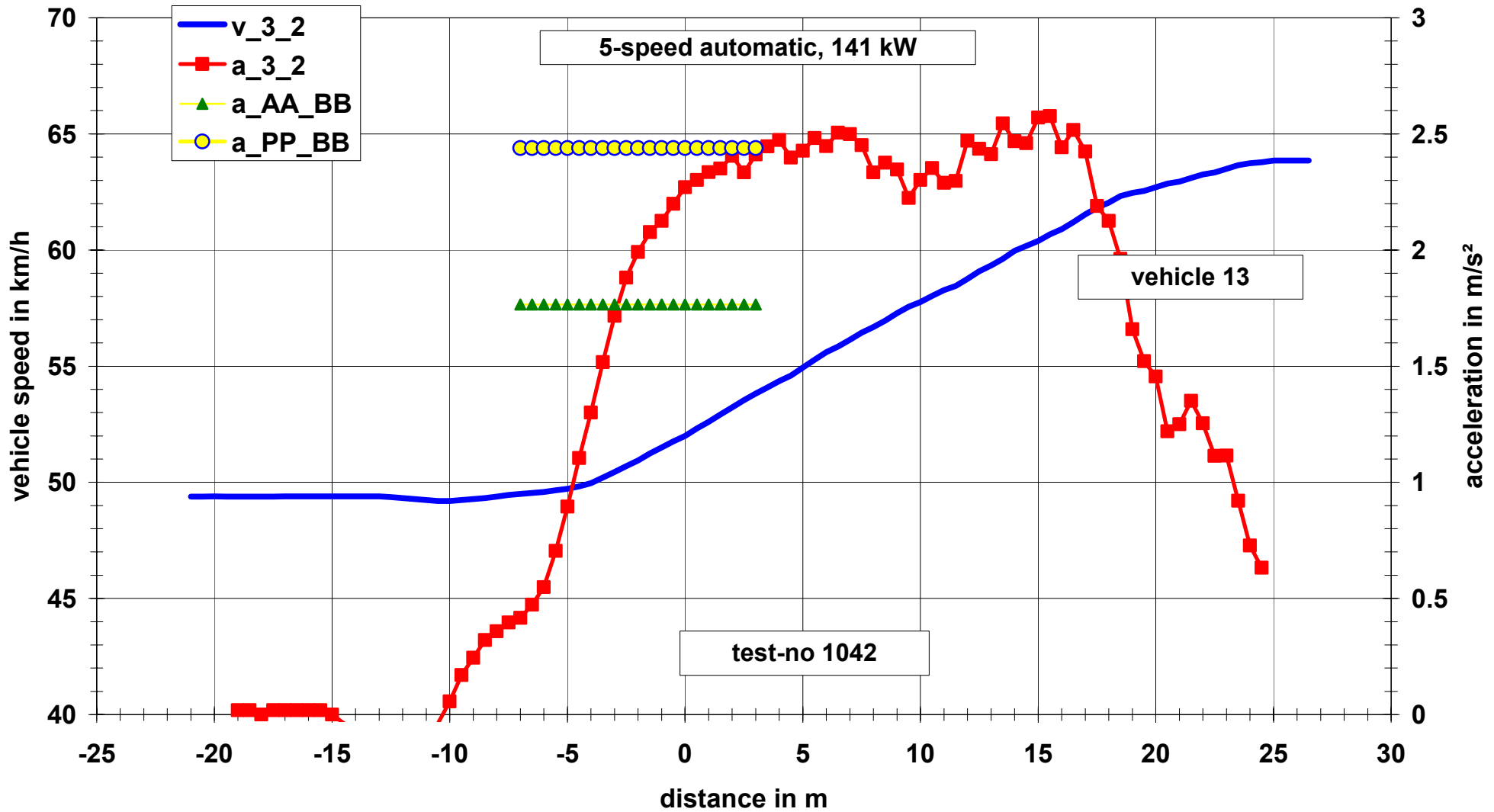
Acceleration Pattern, veh 13, Pn = 141 kW



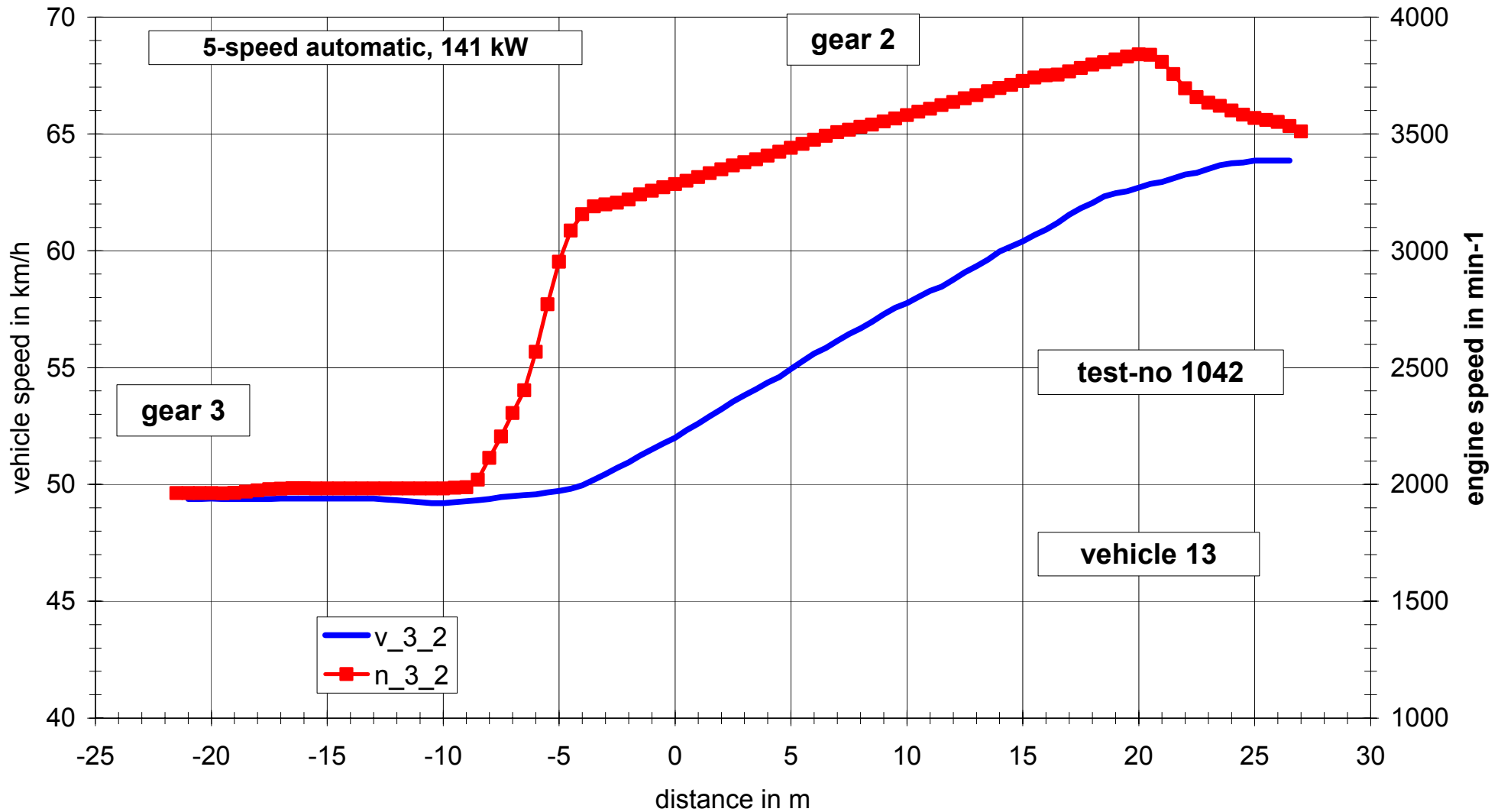
Acceleration Pattern, veh 13, Pn = 141 kW



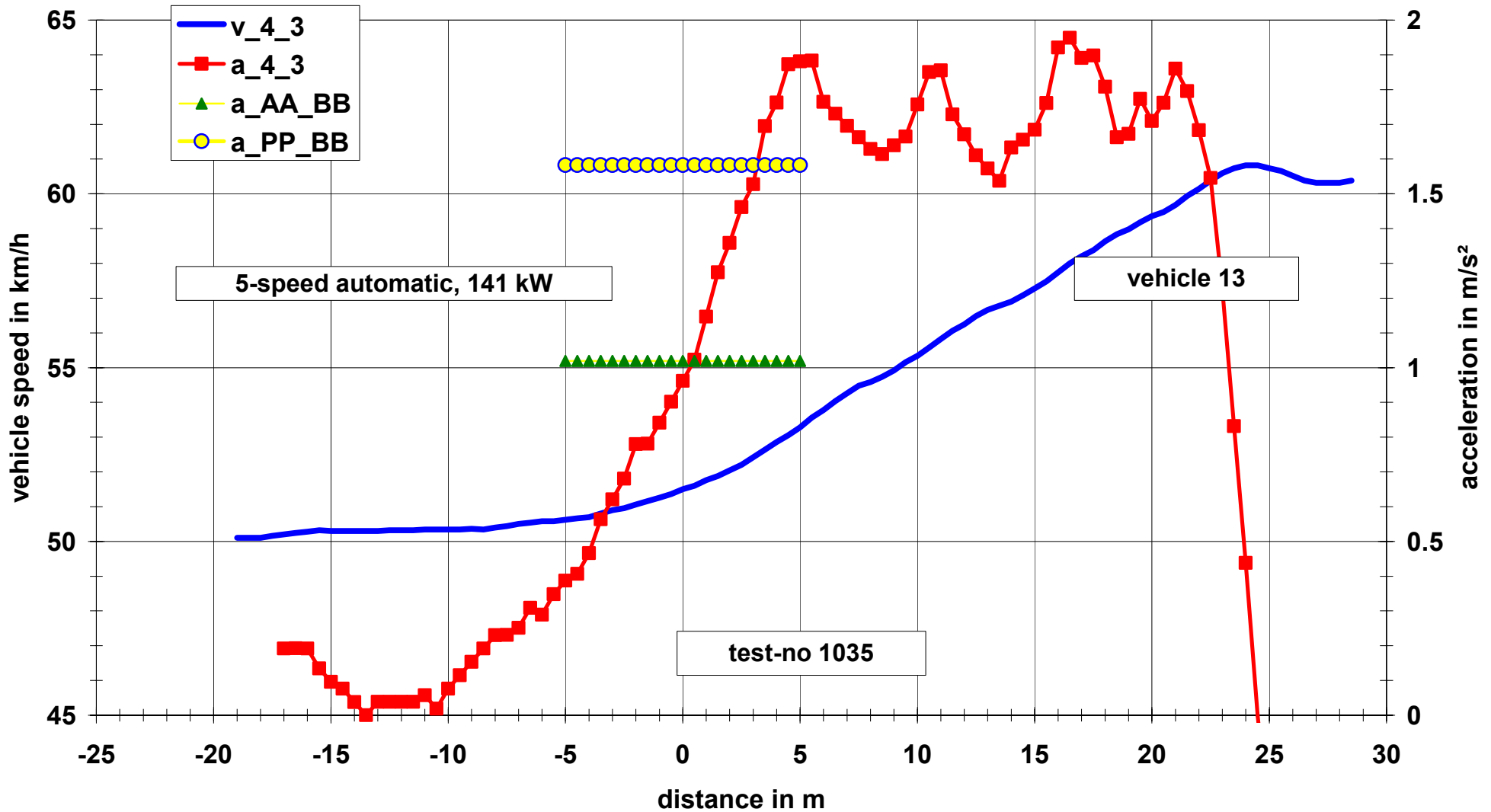
Acceleration Pattern, veh 13, Pn = 141 kW



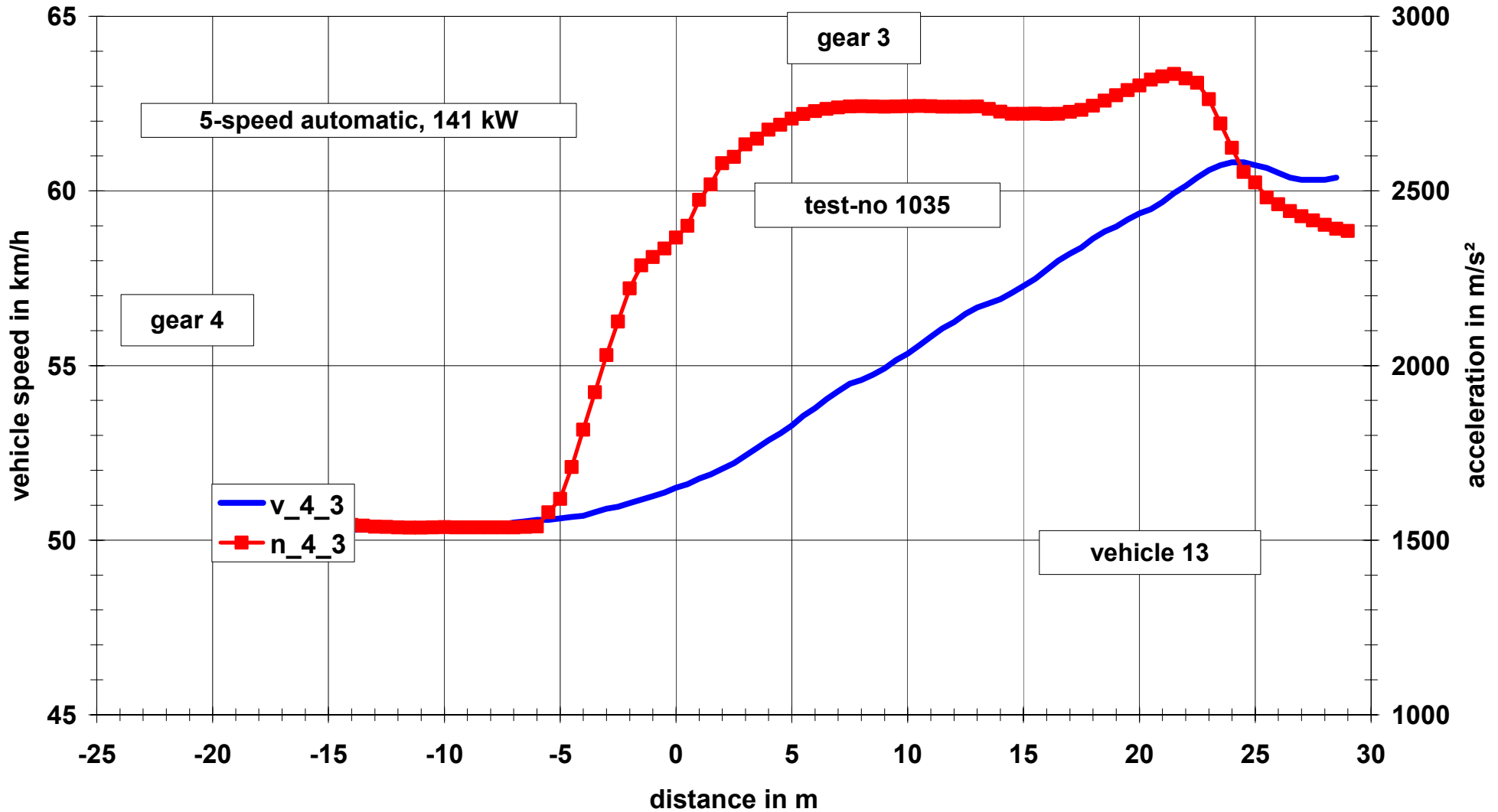
Acceleration Pattern, veh 13, Pn = 141 kW



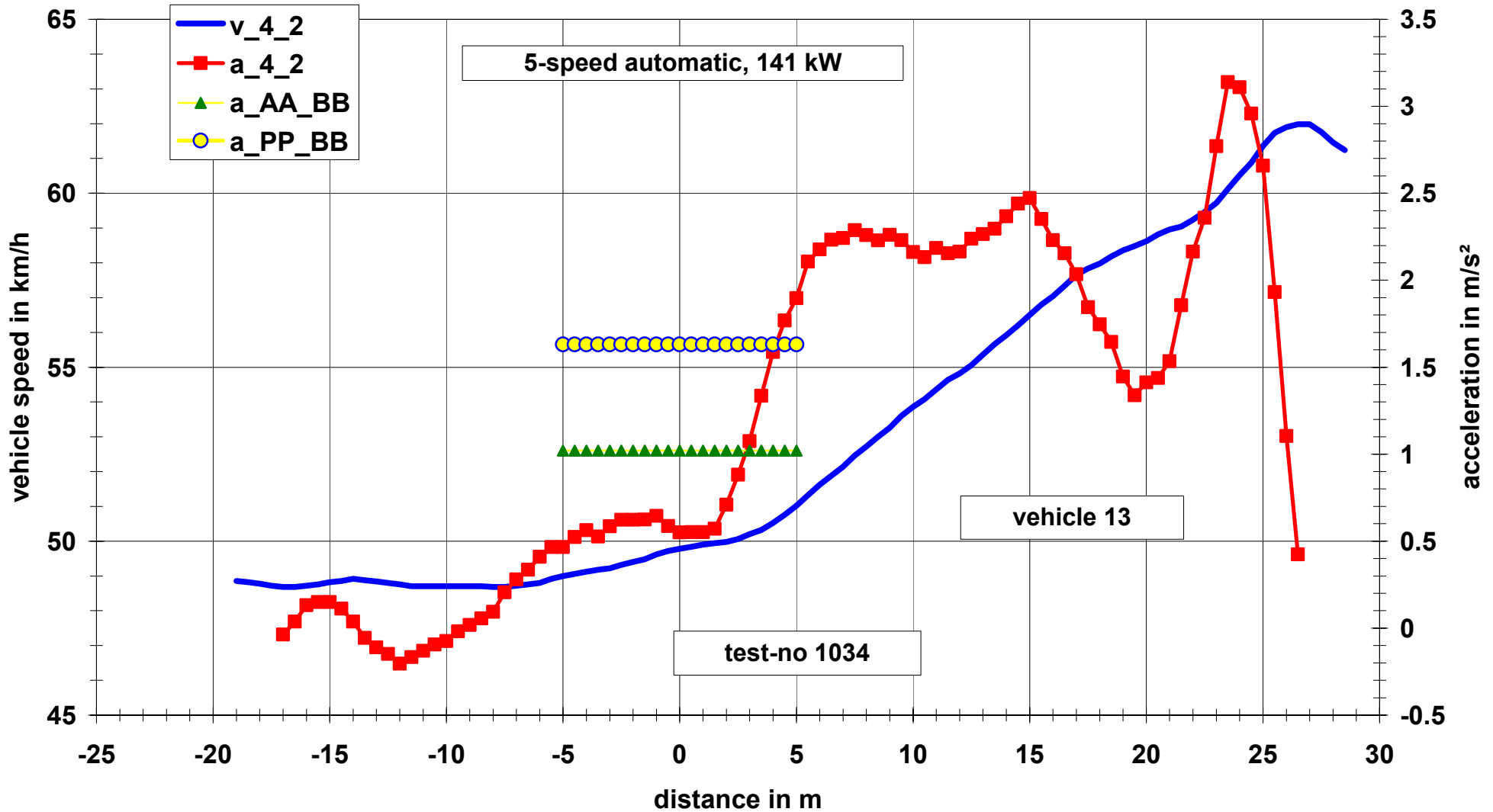
Acceleration Pattern, veh 13, Pn = 141 kW



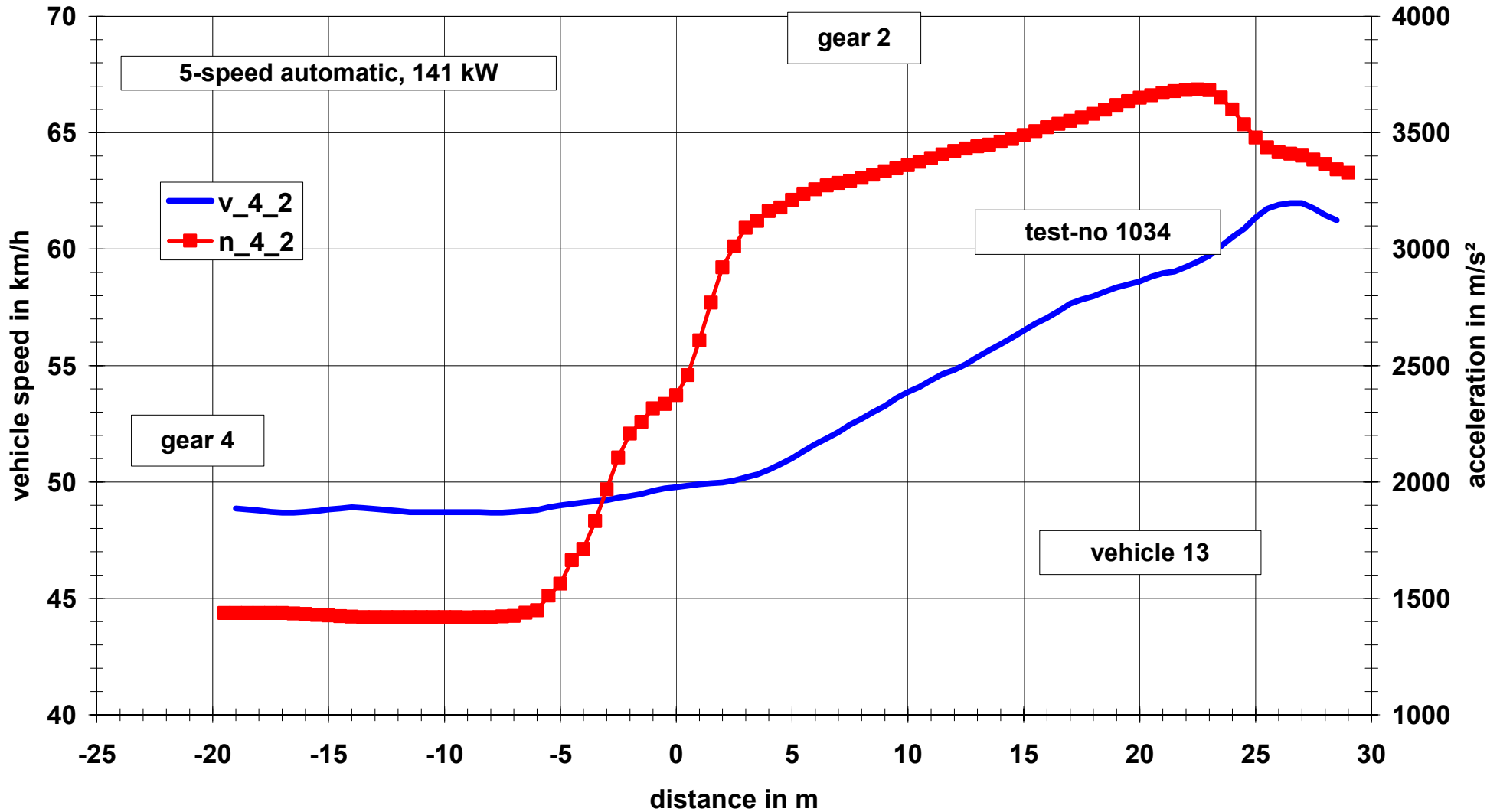
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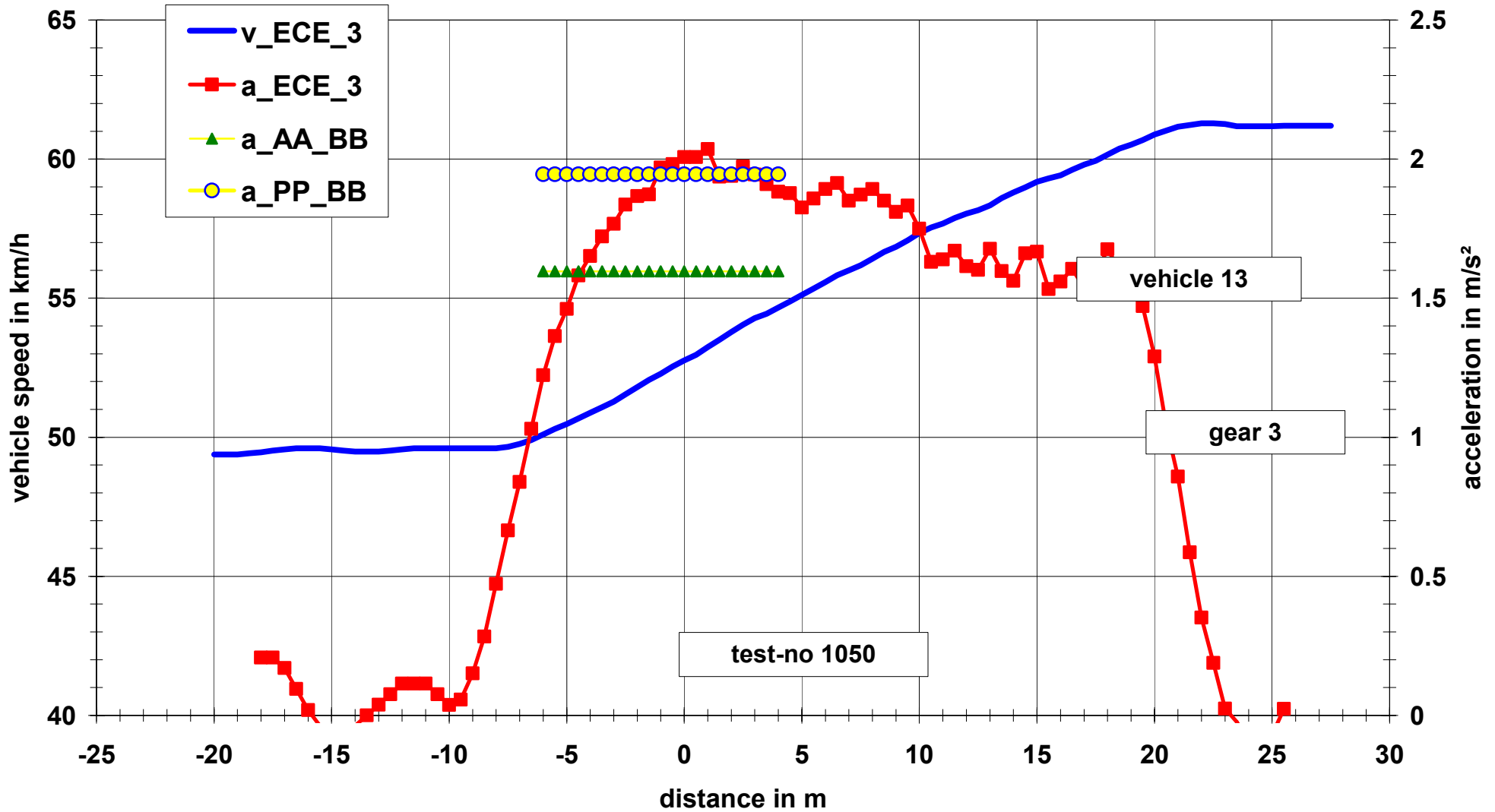
Acceleration Pattern, veh 13, Pn = 141 kW



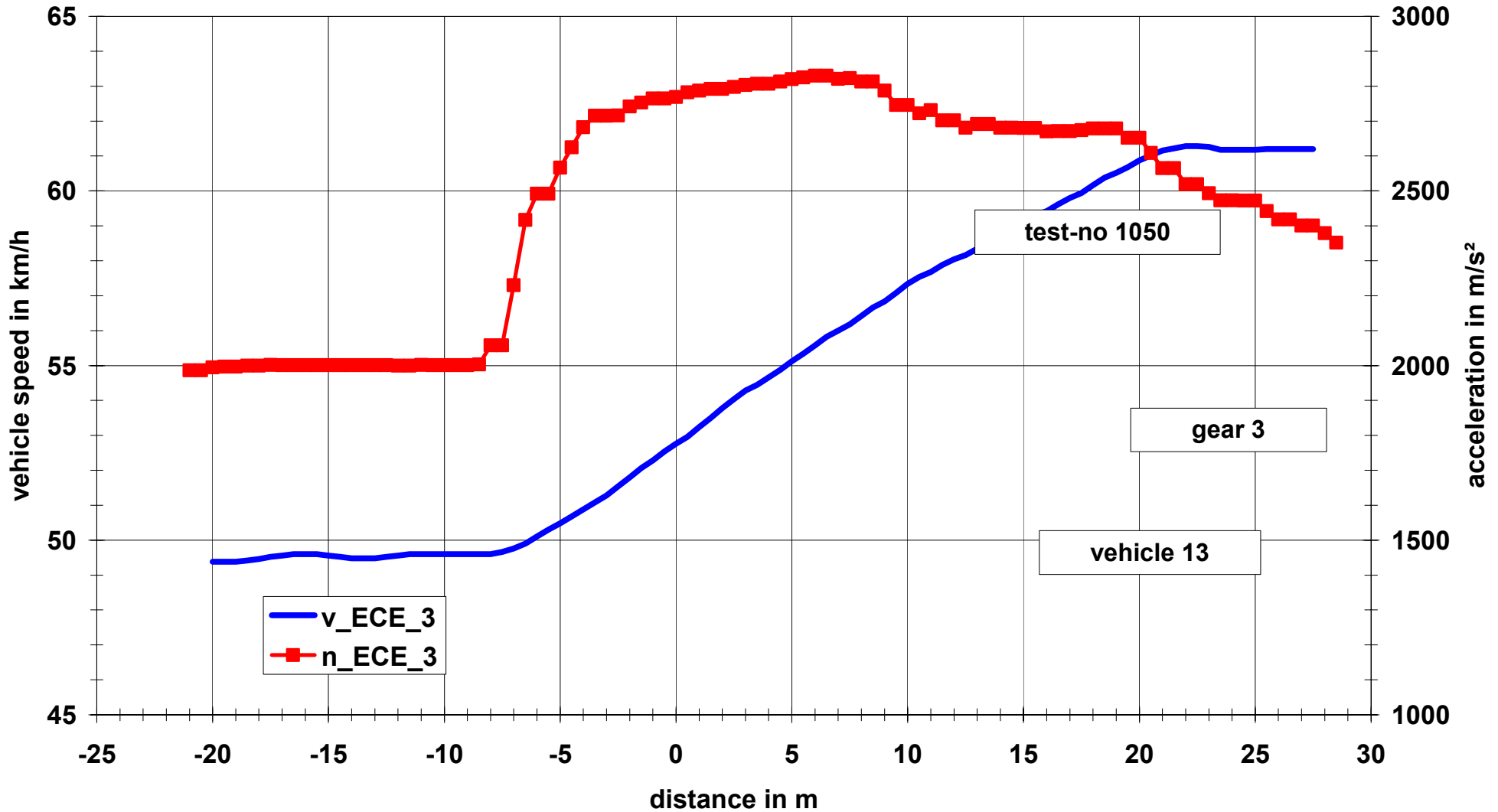
Acceleration Pattern, veh 13, Pn = 141 kW



Acceleration Pattern, veh 13, Pn = 141 kW



Acceleration Pattern, veh 13, Pn = 141 kW



✓ Measurements from $v_{AA} = 20$ km/h:

- 2. Gear was kept with gearbox selector in “drive”. The acceleration increases over the first 6 m from 0 to $3,5 \text{ m/s}^2$ without any significant delay. After that the acceleration decreases slightly with increasing speed.

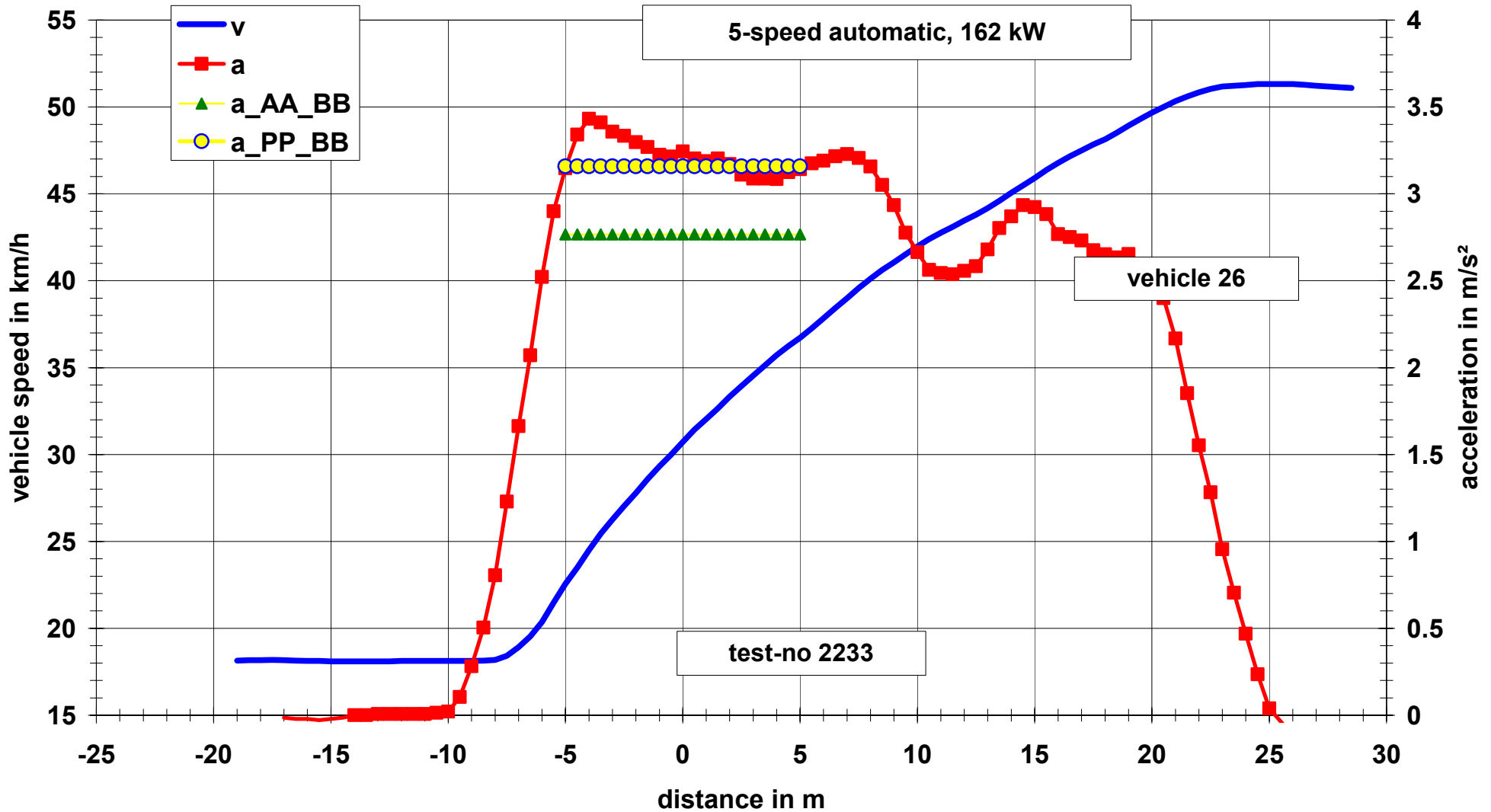
✓ Measurements from $v_{AA} = 50$ km/h:

- in 5 of 7 cases there was a downshift from 5. Gear to 3. Gear. In 2 cases there was a downshift from 5. Gear to 2. Gear. All measurements were carried out in “drive” position. The acceleration between AA and BB varied between 1 m/s^2 to $1,3 \text{ m/s}^2$. The acceleration delay was 12 m in any case.

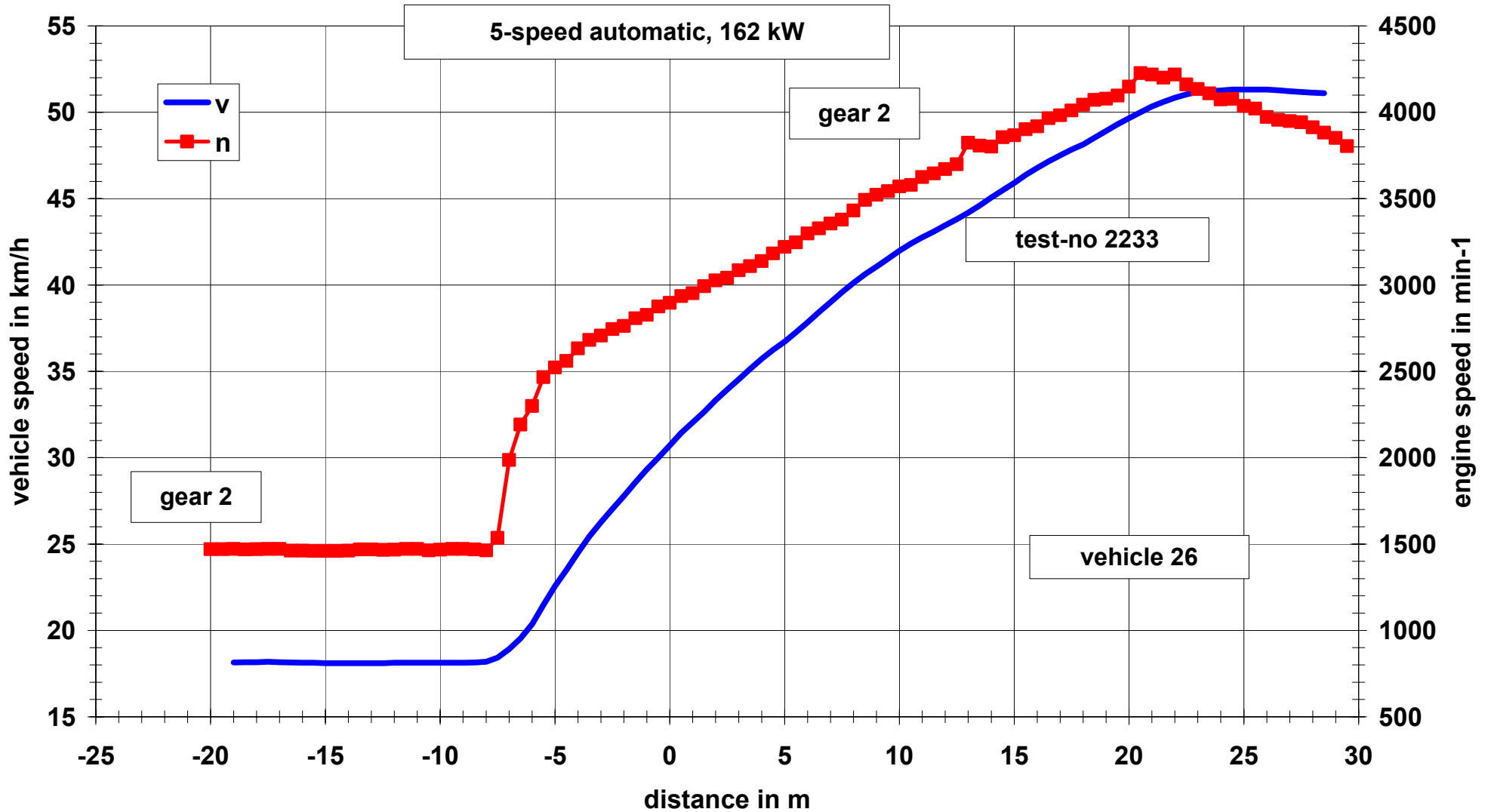
✓ Measurements for the D/ISO method:

- The target acceleration (related to AA_BB) was reached in gear selector position “drive” in 2 of 4 cases. In 3 of 4 cases there was a downshift from gear 5 to gear 3, in 1 case the downshift was from gear 4 to gear 2. The acceleration delay was the same as for the current ECE method (12 m).

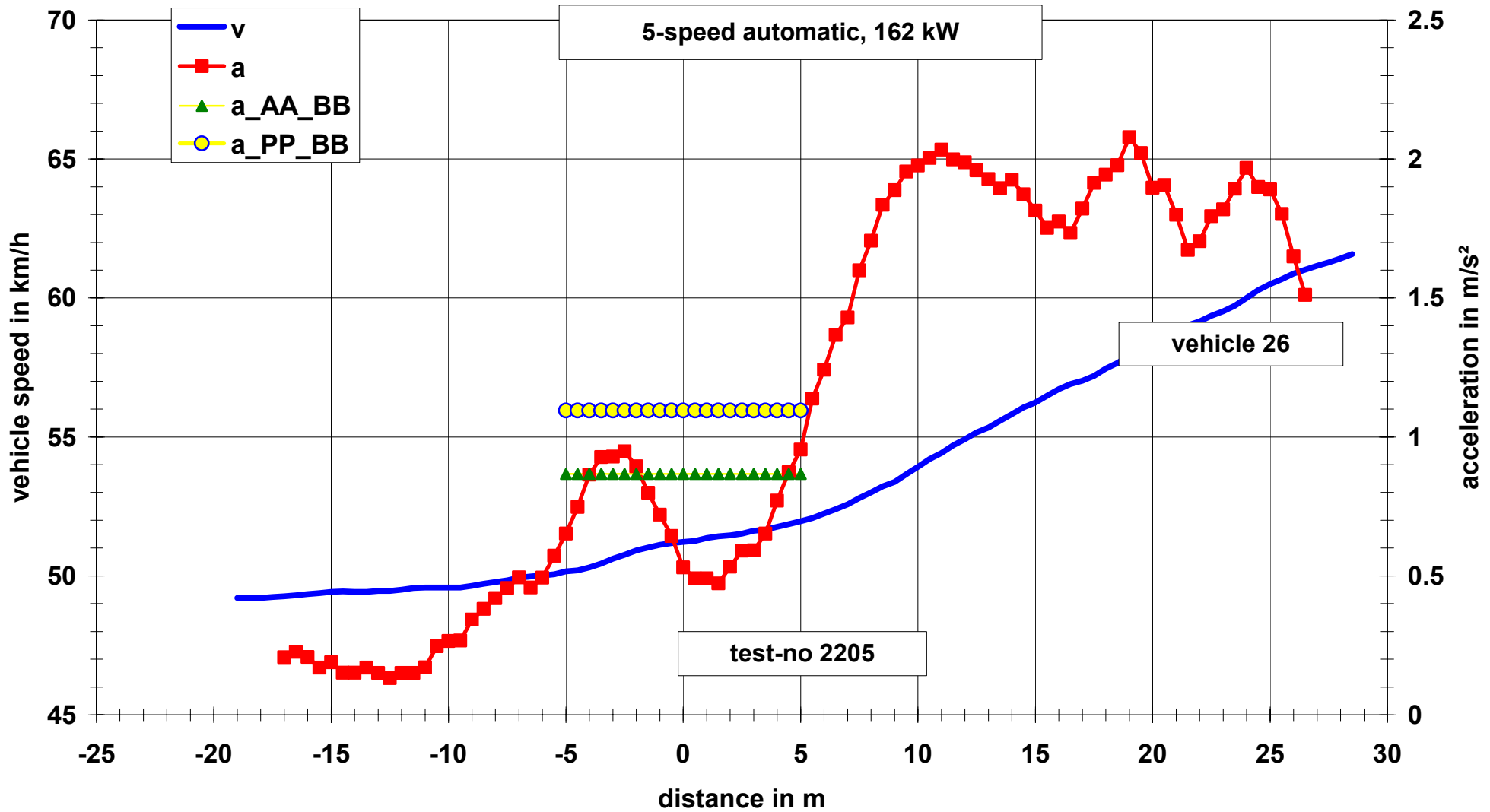
Acceleration Pattern, veh 26, Pn = 162 kW



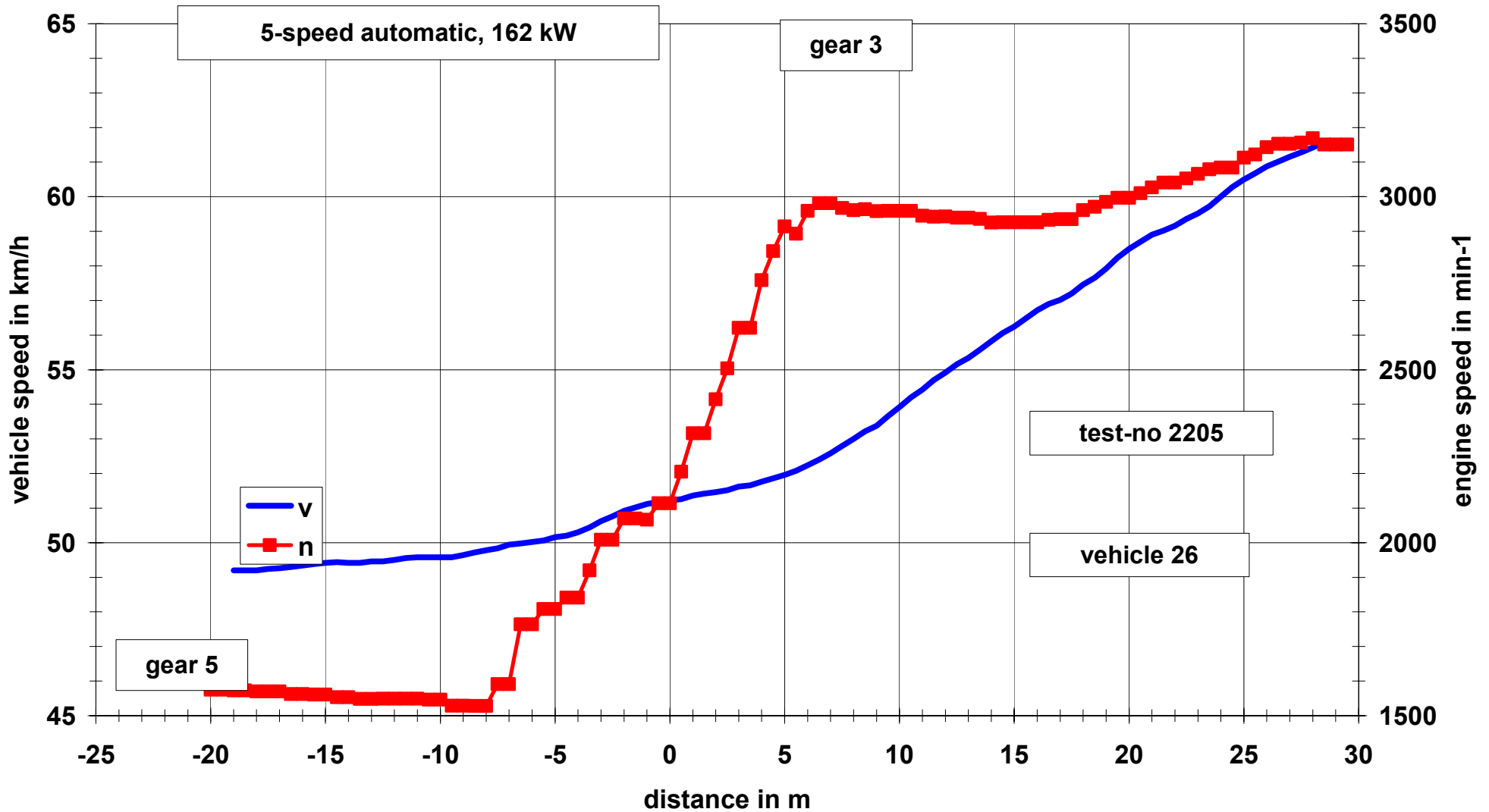
Acceleration Pattern, veh 26, Pn = 162 kW



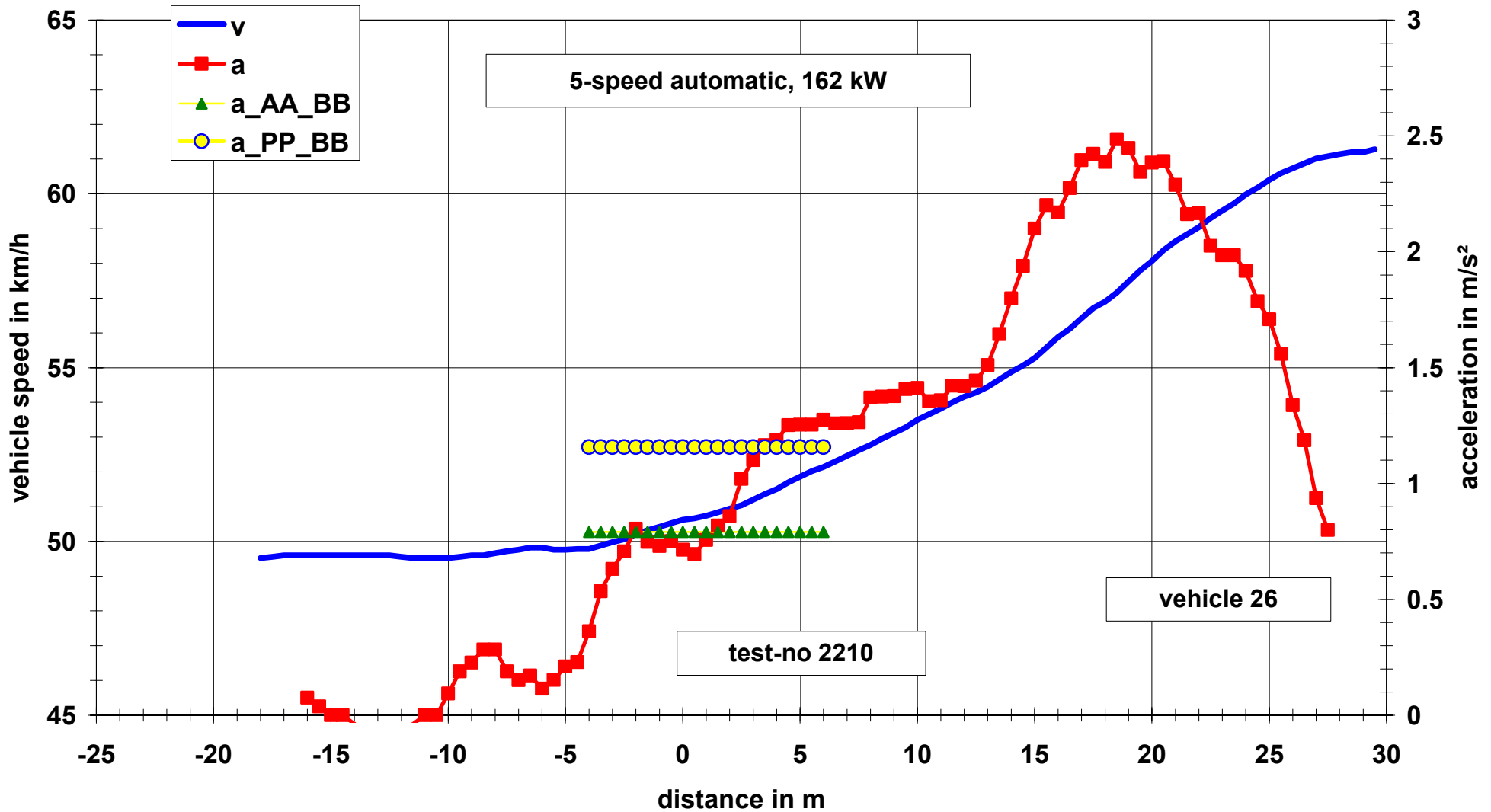
Acceleration Pattern, veh 26, Pn = 162 kW



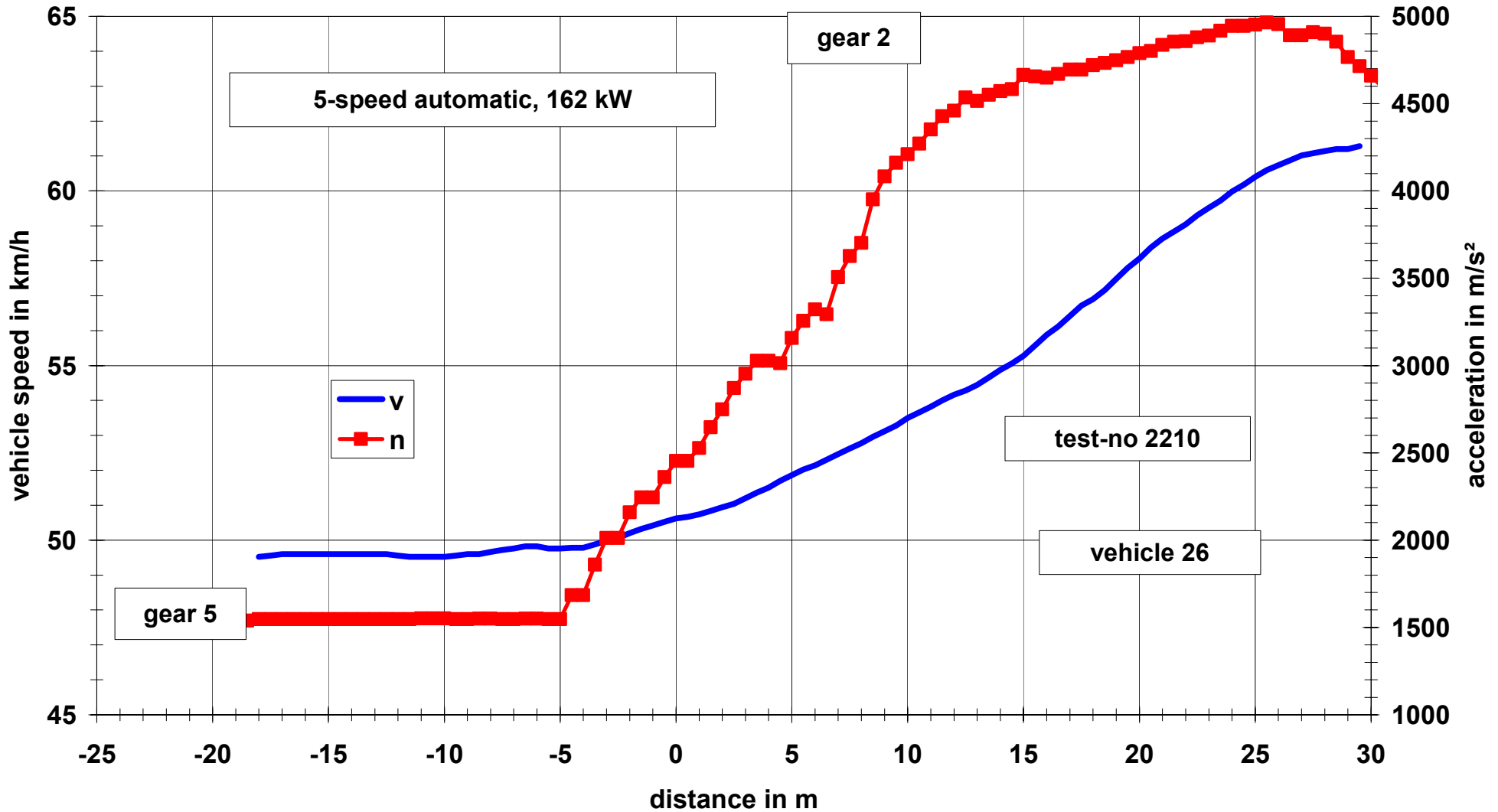
Acceleration Pattern, veh 26, Pn = 162 kW



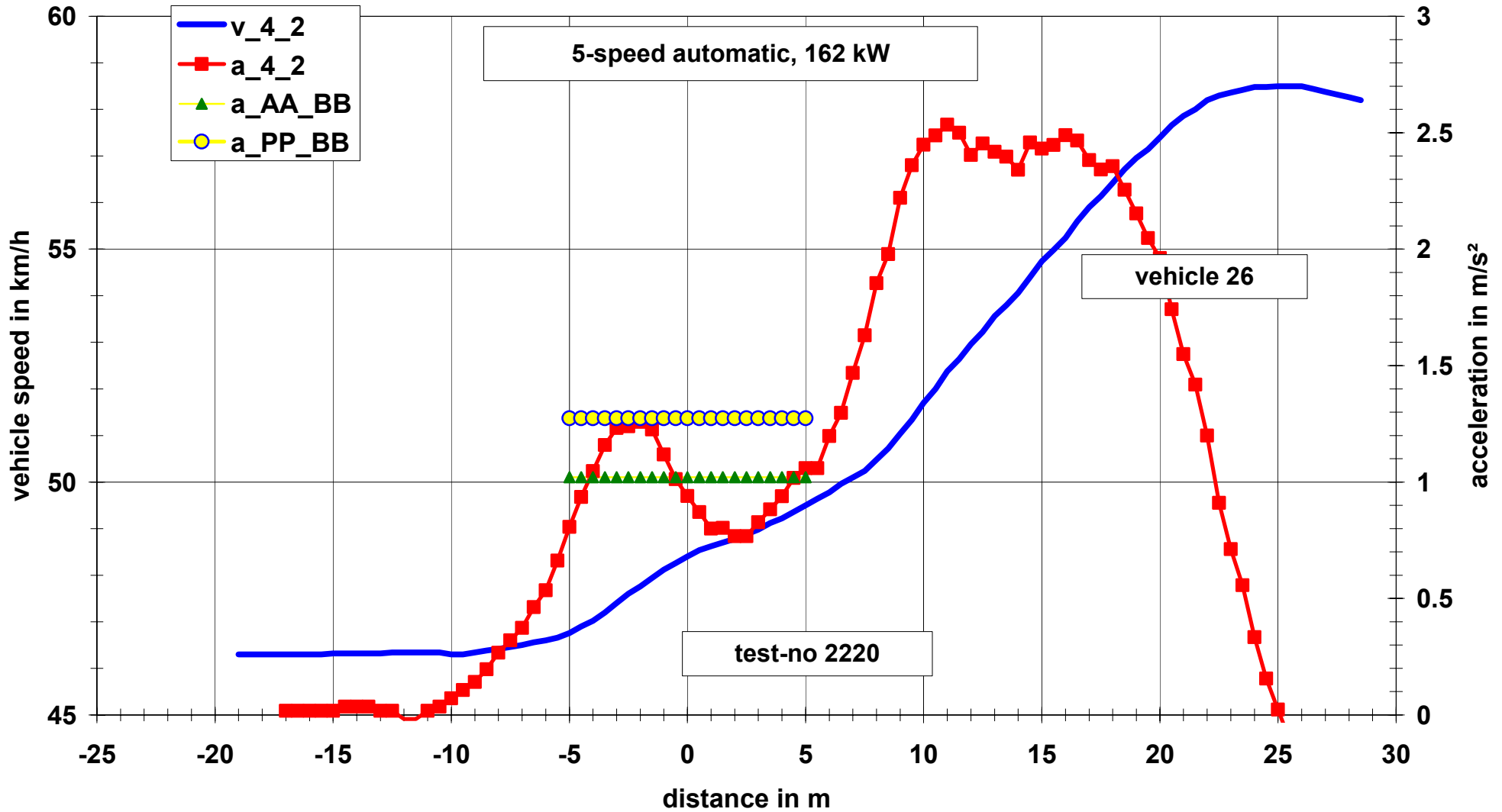
Acceleration Pattern, veh 26, Pn = 162 kW



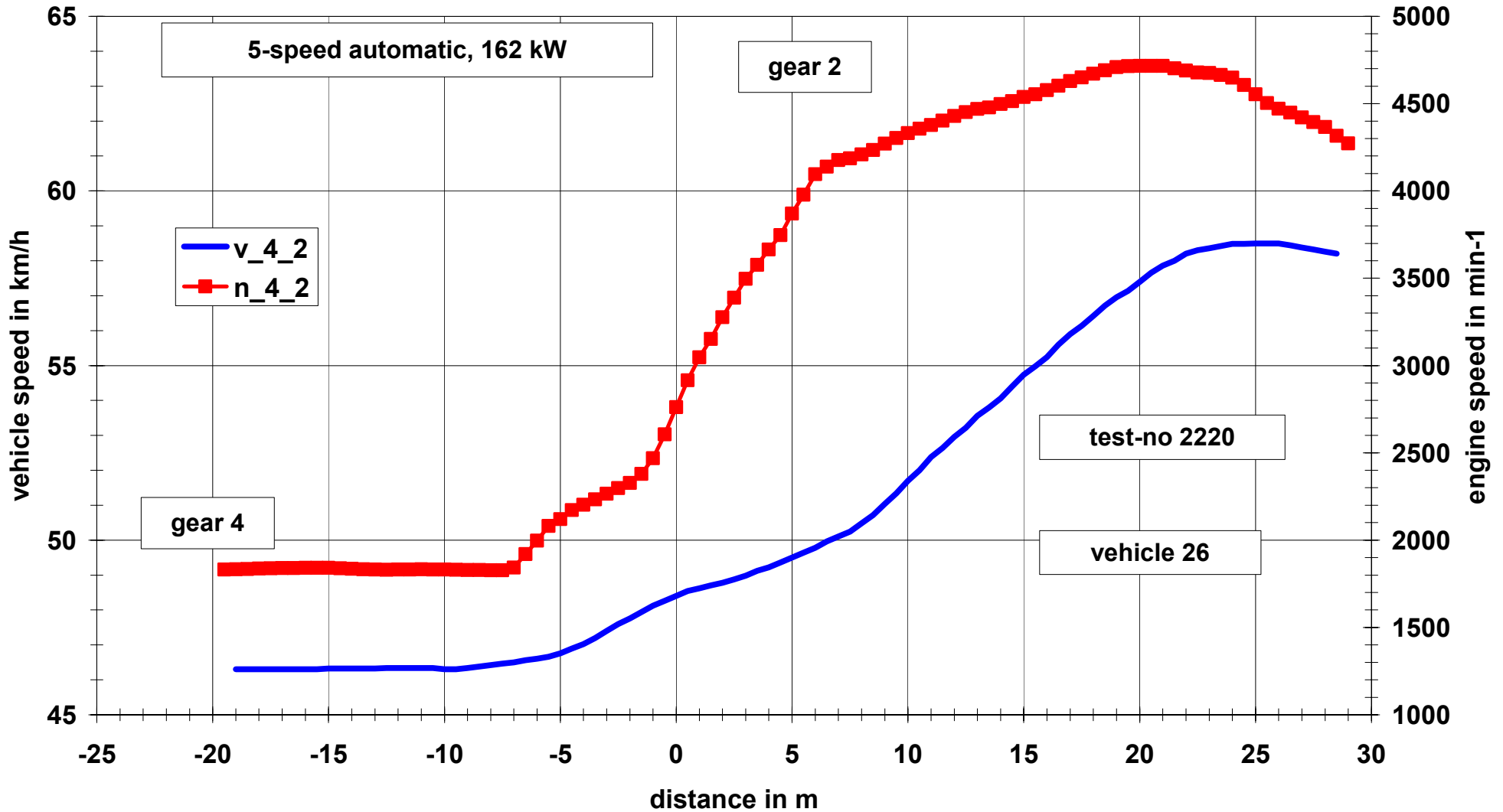
Acceleration Pattern, veh 26, Pn = 162 kW



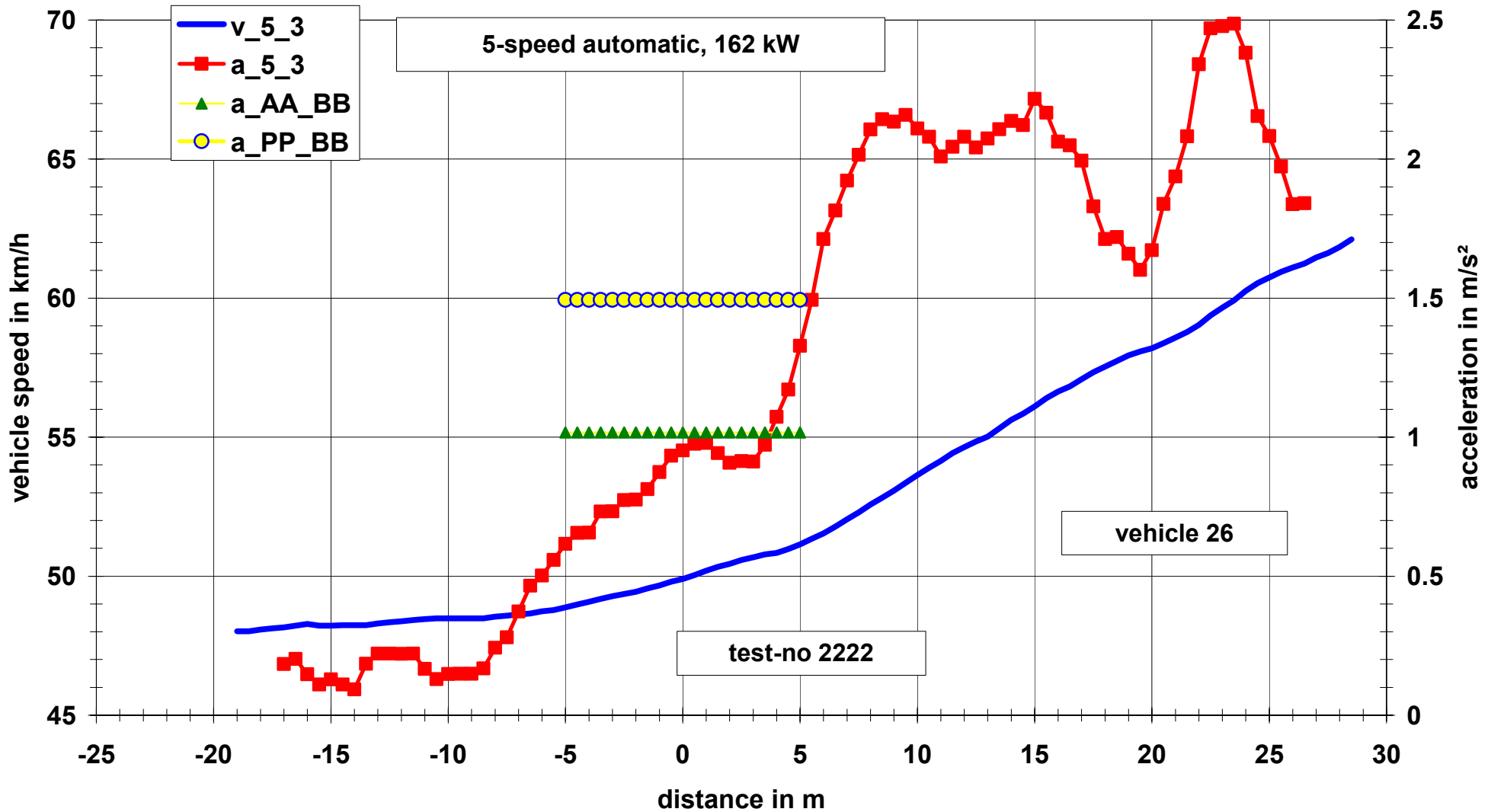
Acceleration Pattern, veh 26, Pn = 162 kW



Acceleration Pattern, veh 26, Pn = 162 kW



Acceleration Pattern, veh 26, Pn = 162 kW



Acceleration Pattern, veh 26, Pn = 162 kW

