# A Review of Self-Contained Self-Rescuer Research

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## Self-Contained Self-Rescuer (SCSR)

- Provides oxygen for emergency escape
- Supposed to supply at least 60 minutes of oxygen

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- **CSE SR-100**
  - Contains Potassium Superoxide ($KO_2$)
  - Chemical reaction that generates oxygen from moisture in exhaled breath ($H_2O$)

$$2KO_2 + H_2O \rightarrow 2KOH + 1.5O_2$$

  - Carbon Dioxide ($CO_2$) from exhaled breath reacts to form more water vapor, which reacts to form additional oxygen

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$



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- SCSR wearers are required to walk at a controlled pace so oxygen supply does not outpace the rate of oxygen use
- Enough oxygen is supplied to keep up with the rate of work **IF** **breathing air** is **proportional** to **oxygen demands**

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- **What happens at high work rates?**
  - Breathing air is disproportionate to oxygen usage rate
  - Oxygen generating capacity is used up at a much faster rate
  - Extra oxygen is wasted to atmosphere



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## Two UMD Studies

### 1) How Far Can One Walk Wearing a Self-Contained Self-Rescuer?

- **Goal:** Determine the distance that can be walked when using SCSRs as intended
- **Discovered:**
  - Average Distance = 3.7 miles
  - Allows estimable distance to place additional SCSRs on route

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## 2) Using Self-Contained Self-Rescuers at High Work Rates

- **Goal:** Examine effect of exercise intensity on performance time while wearing CSE SR-100
- **Discovered:**
  - SCSRs used outside of recommended range incur severe penalties



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## How Far Can One Walk Wearing a Self-Contained Self-Rescuer?

**60 minutes of oxygen = what distance?**

**Answer (average result):**

**6.0 km (3.7 miles)**

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- 14 volunteer subjects
- PAR-Q health assessment form
- Maximum oxygen uptake in range of average fitness levels (2.7-3.2 L/min)
- Treadmill walking, 0% Grade
- Speed determined by subjects (had to meet rate of oxygen supplied)
- Instructed to walk as long as possible



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- **Results**
  - Distances
    - **Maximum** distance obtained = **9.2 km** (5.7 miles)
    - **Minimum** distance obtained = **2.1 km** (1.3 miles)
    - **Average** of **6.0 km** (3.7 miles)



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- **Results** ***(cont'd)***
  - Times
    - 30 minutes to 94 minutes
    - **Average** of **65 minutes**

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**Subject Performance Data**

| Subject | Time (min) | Distance (miles) | Termination Reason |
|---|---|---|---|
| 1 | 57 | 2.9 | insufficient air |
| 145 | 59 | 3.5 | none given |
| 292 | 50 | 2.4 | insufficient air |
| 340 | 73 | 4.4 | difficult to inhale |
| 343 | 69 | 4.2 | air too hot |
| 358 | 67 | 4.3 | air too hot |
| 401 | 46 | 3 | none given |
| 402 | 75 | 4.2 | none given |
| 404 | 71 | 4.7 | none given |
| 406 | 30 | 1.3 | insufficient air |
| 409 | 69 | 3.7 | difficult breathing |
| 410 | 81 | 3.4 | air too hot |
| 411 | 90 | 5.6 | difficult breathing |
| 412 | 94 | 5.1 | insufficient air |
| Avg. | 65 | 3.7 | |



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- **Results** *(cont'd)*
  - Speeds
    - Began at 1.3 m/sec (3.0 mph) and adjusted for each subject
    - Found no correlation between speed and distance walked

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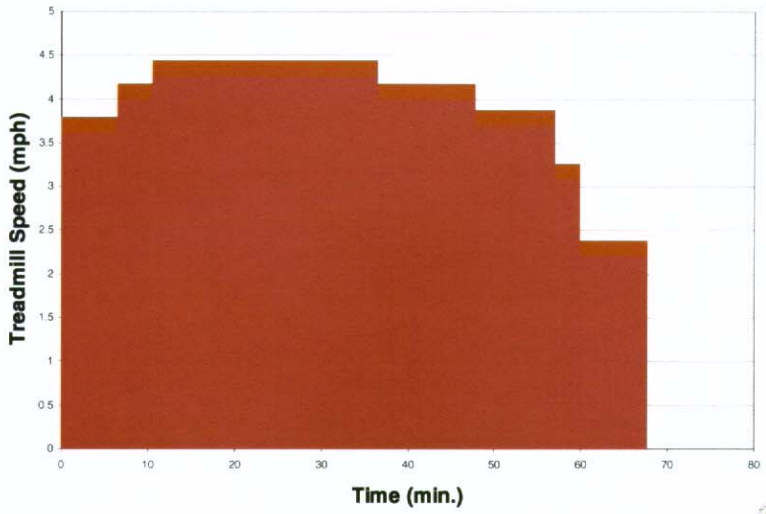




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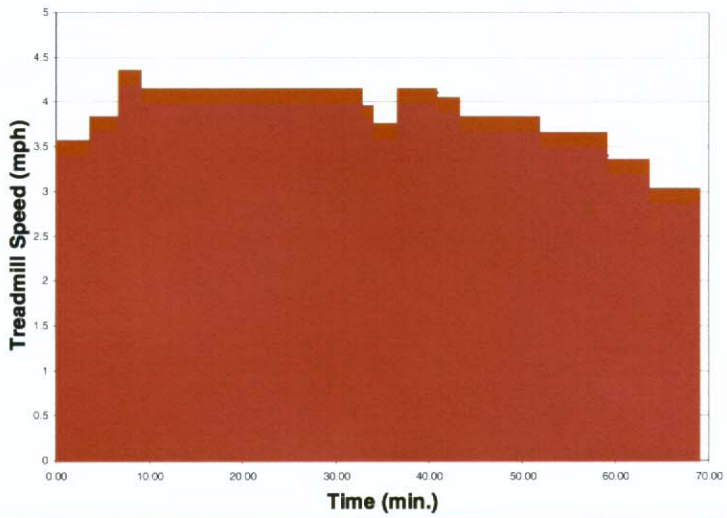


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- **Subject Complaints (SR-100)**
  - Unit gets very hot
  - Inhaled air uncomfortably warm
  - Inhaled fine, gritty material
  - High resistance toward end
  - Difficulty keeping nose clip on
  - Mouthpiece uncomfortable



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- **Conclusion**
  - Additional SCSRs should be stationed at locations along route
  - Extra SCSRs should be available to carry from the beginning of the escape

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- **Conclusion *(cont'd)***
  - Training is very important
    - Potential wearers should know about device limitations
    - Potential wearers should practice with the units
      - Become familiar with SCSR and aware of complaints listed
      - Additional practice would increase performance times and distance



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# Using Self-Contained Self-Rescuers at High Work Rates

**With controlled pace walking, oxygen should be available for 60 minutes.**

**What happens…**

**High Speeds = X minutes Oxygen??**

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- One volunteer subject, $\dot{V}O_2\ \max = 3.0 L/\min$
- Treadmill walking, 0% Grade
- Five testing sessions, each at varied intensities
  - 65, 70, 75, 80, and 85% $\dot{V}O_2\ \max$
- Instructed to exercise until fatigue or until equipment limitations were reached



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- **Results**
  - Performance times **decrease linearly** as oxygen consumption increased
  - No performance time reached 60 minutes
  - All work rates were **too high** for SCSR
  - Cause of exercise termination reported to be lack of supply from SCSR

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## Experimental Data

| % VO2 Max | Performance Time (min) | Minute Volume (L/min) |
|---|---|---|
| 65% | 45.7 | 50 |
| 70% | 40.5 | 56 |
| 75% | 28.4 | 62 |
| 80% | 10.4 | 68 |
| 85% | 6.5 | 75 |



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## Experimental Data

| % VO2 Max | RPE | | BACS | |
|---|---|---|---|---|
| | 6 min | term | 6 min | term |
| 65% | 13 | 20 | 5 | 2 |
| 70% | 12 | 19 | 5 | 0 |
| 75% | 15 | 20 | 3 | 0 |
| 80% | 15 | 19 | 2 | 0 |
| 85% | 19 | 20 | 1 | 1 |

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- **Calculated Data**
  - **Performance time** (Kamon Formula)

$$t_{perf} = 120\left(\frac{\dot{V}O_2\,max}{\dot{V}O_2}\right) - 117$$

  - **Time penalty** = $t_{penalty} = t_{perf_{calc}} - t_{perf_{meas}}$
  - **Distance walked** = $(t_{perf_{meas}})$(treadmill speed)
  - **Oxygen used** = (oxygen consumption)$(t_{perf_{meas}})$



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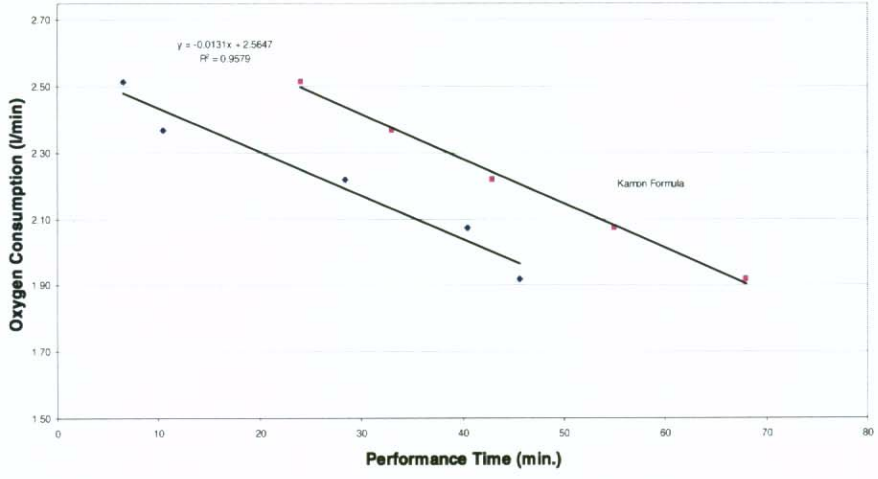


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- **Discussion**
  - **Emergency situation = panic = increased work rates**
  - **Penalty** for increased work rate:
    - SCSR much more uncomfortable
    - Effort more difficult
    - Much lower amount of accessible oxygen
    - Much shorter performance time
  - **Therefore**: Use SCSR at low rates of work (oxygen used is matched by oxygen generation)



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- **Conclusion**
  - Inverse relationship exists between performance time and exercise intensity
  - Confirmed SCSR must be used as intended
  - Penalty can be expected if SCSR is used outside its range

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# Overall Conclusion

- In emergency situation, **DON'T PANIC!!!**
- Use SCSR as intended→at **LOW** work rates
- **TRAIN! TRAIN! TRAIN!** Become familiar and aware of SCSR limitations
- Additional SCSRs should be stationed at locations along route

AND/OR

- Extra SCSRs should be available to carry from the beginning of the escape